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PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

JUNE 1959

VOLUME 42 • NUMBER 6

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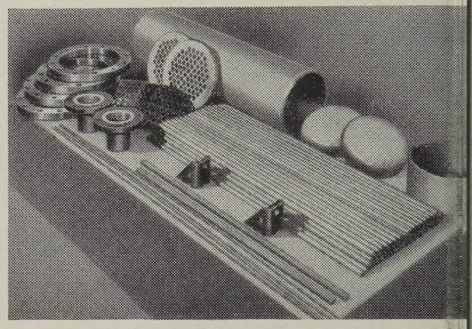

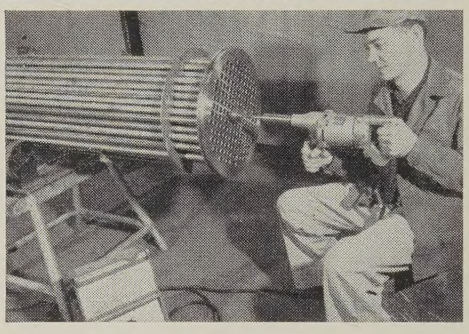

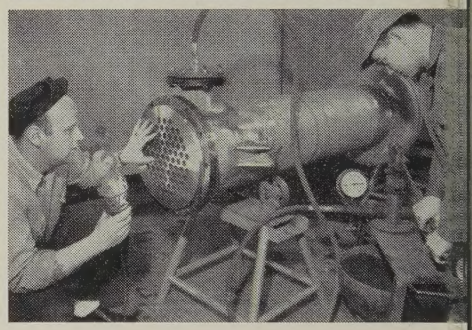

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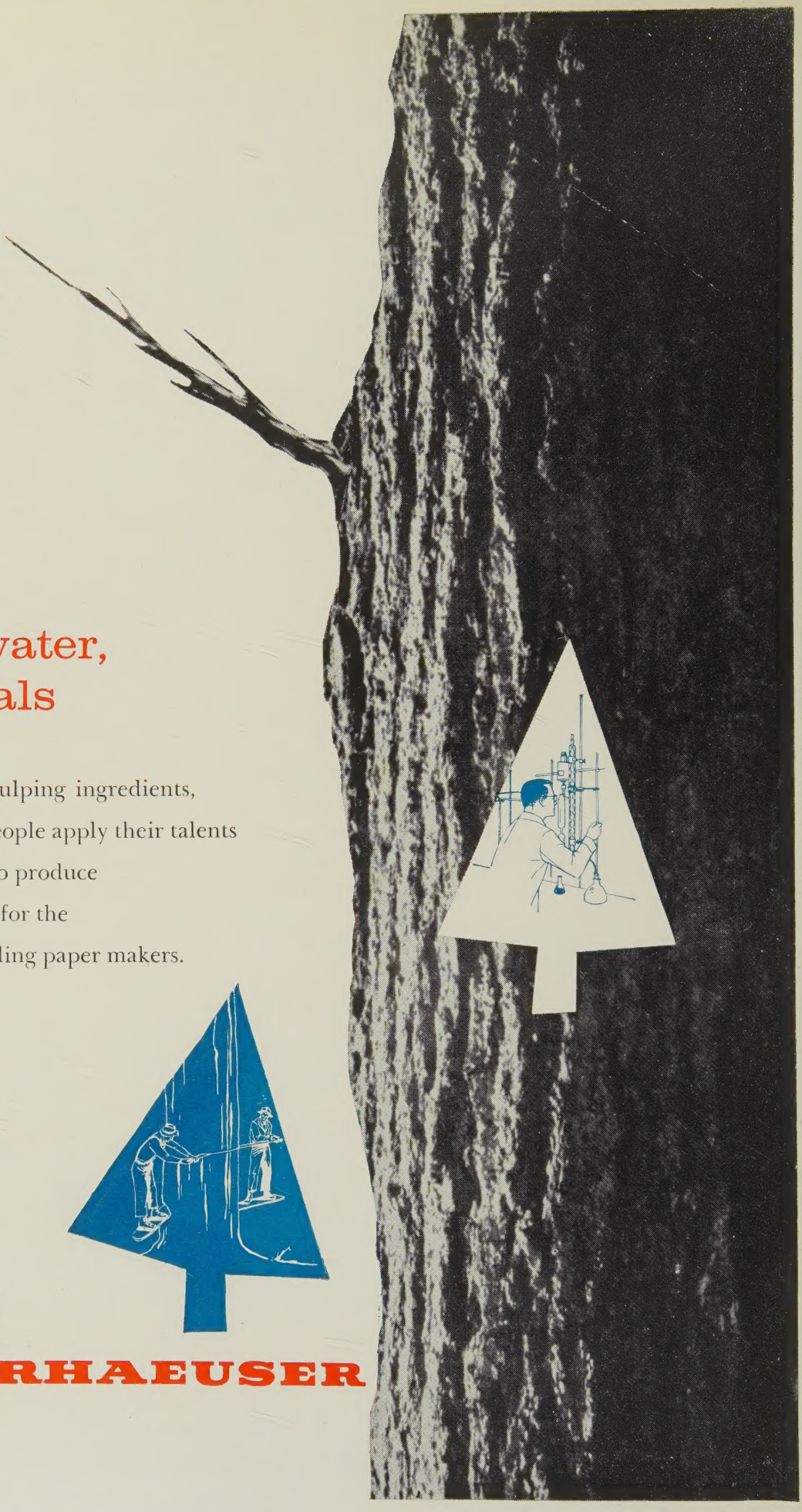

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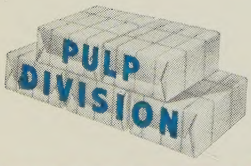

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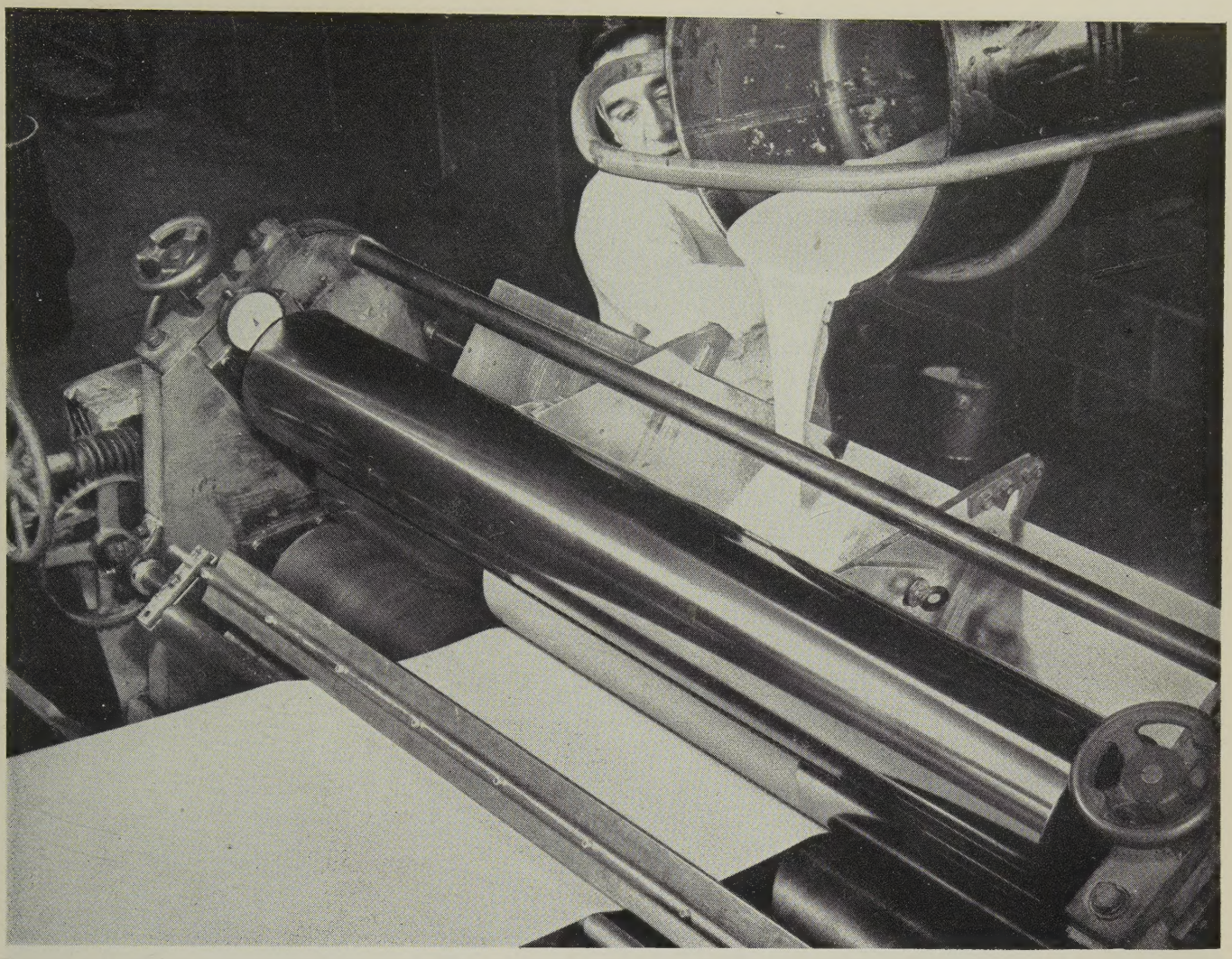

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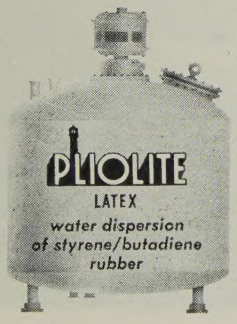

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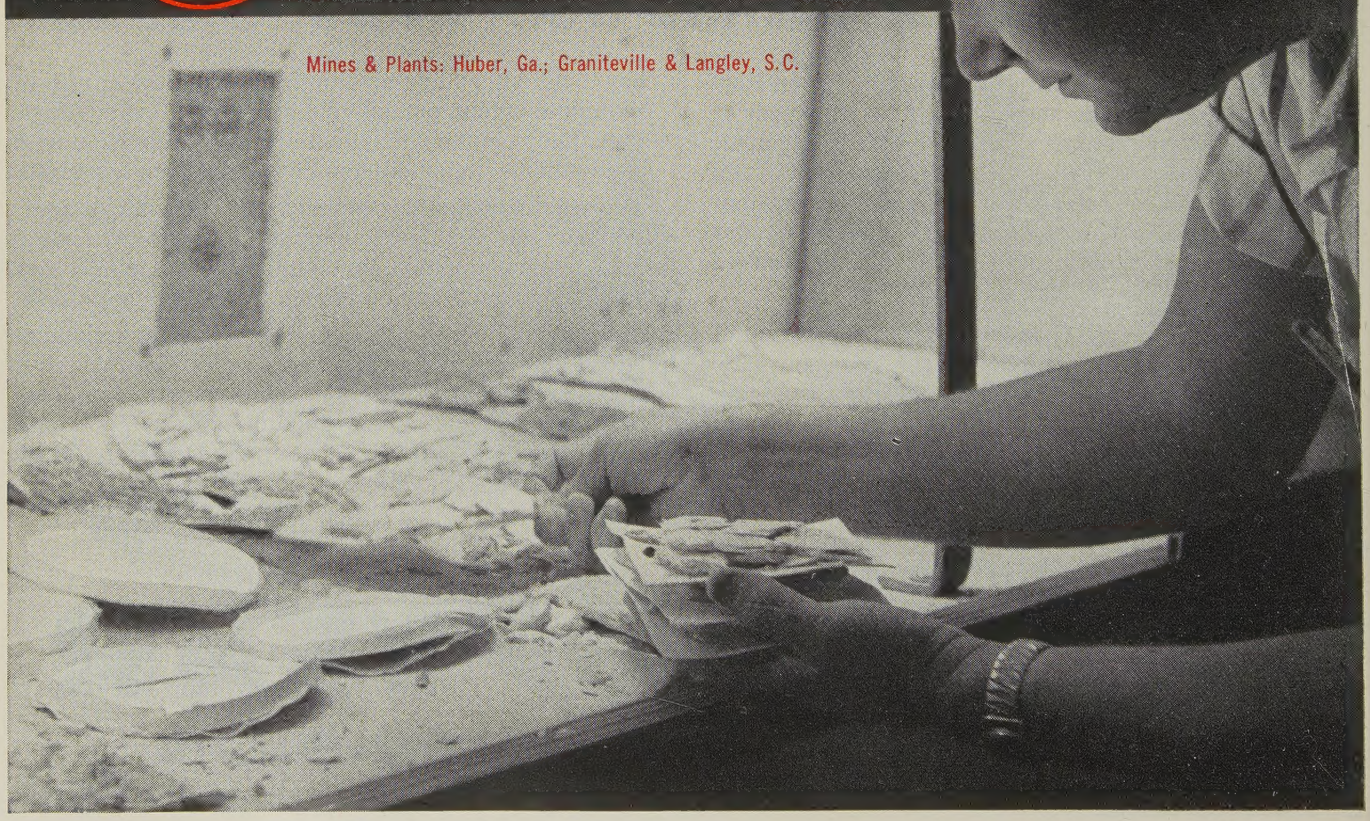

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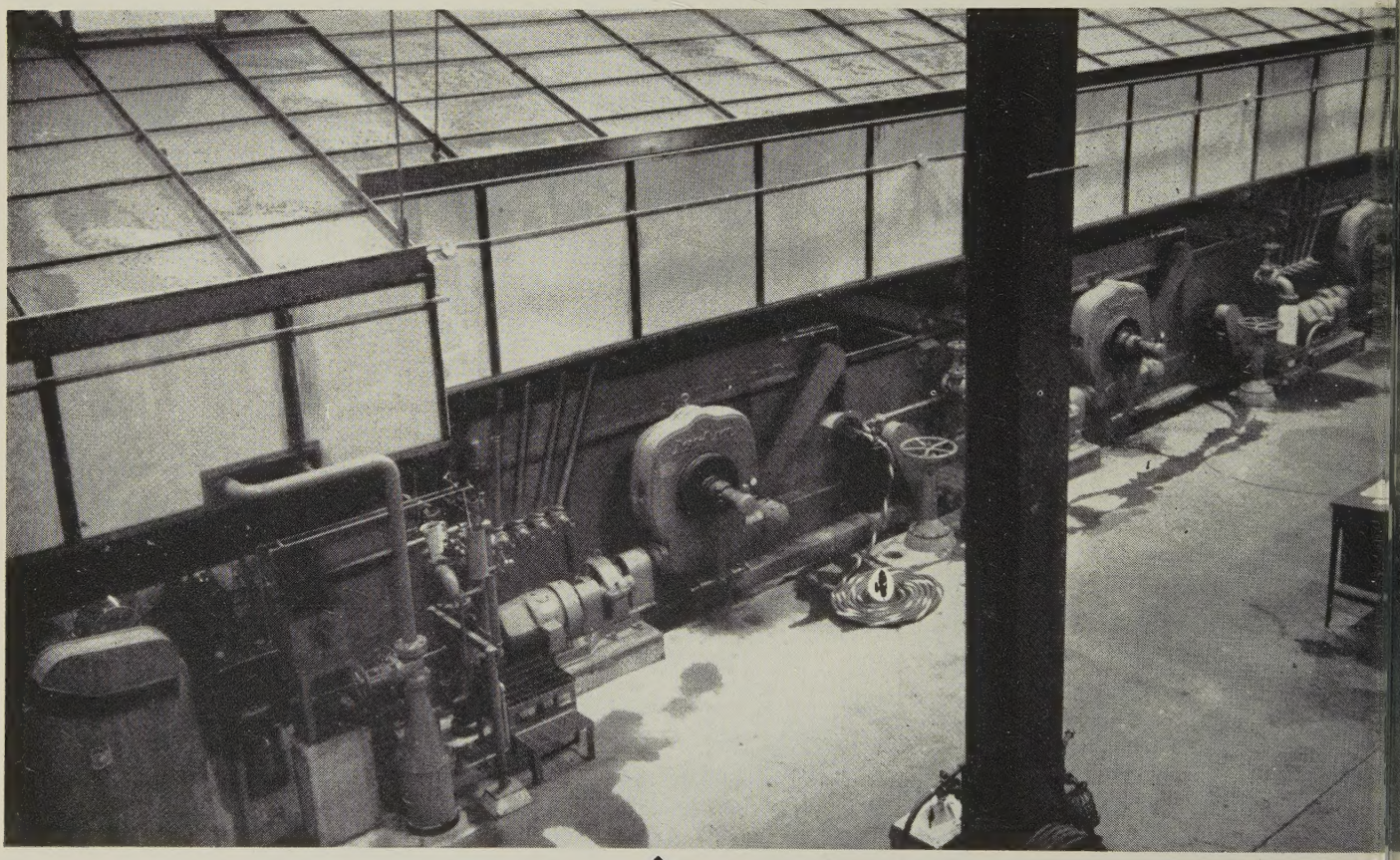

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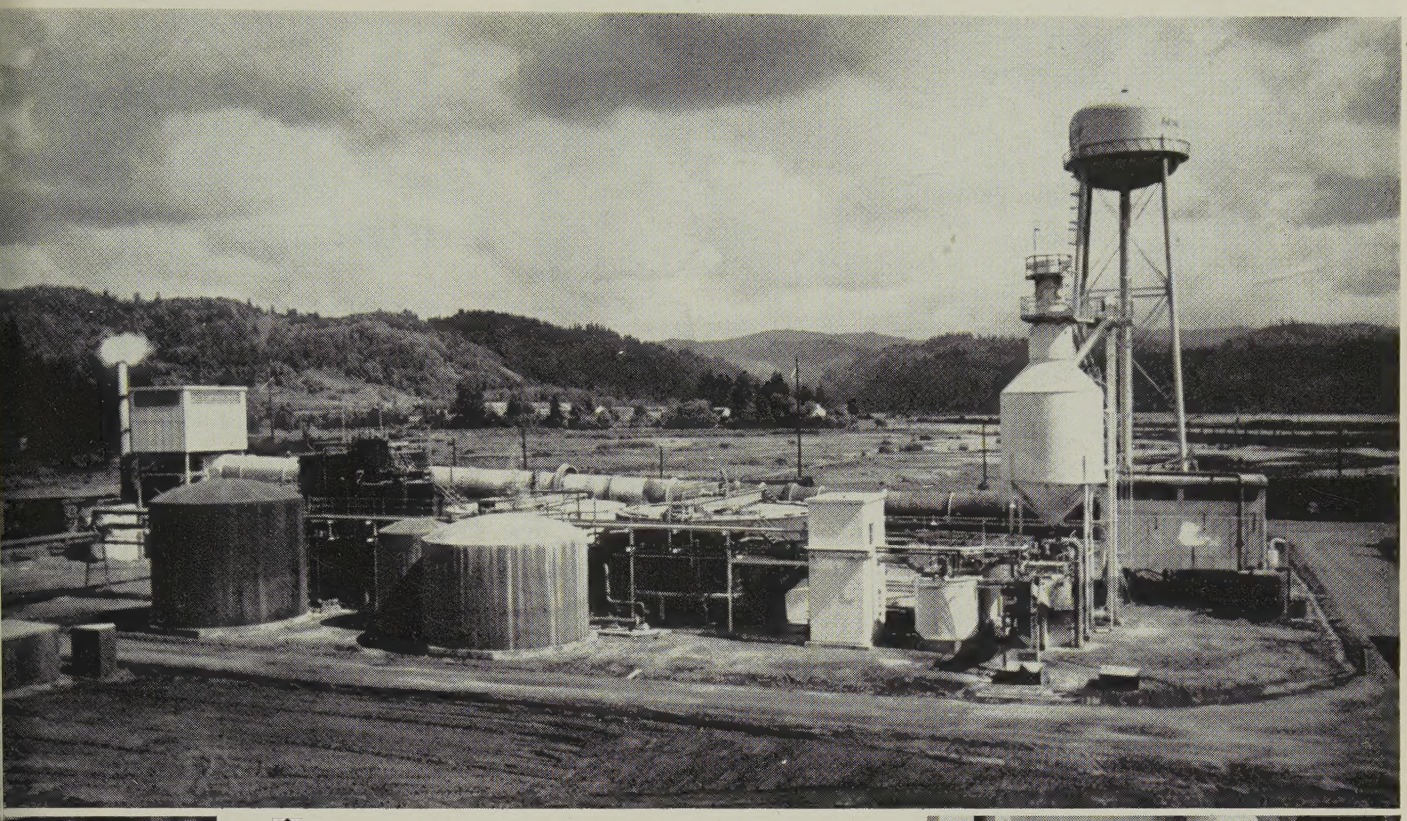

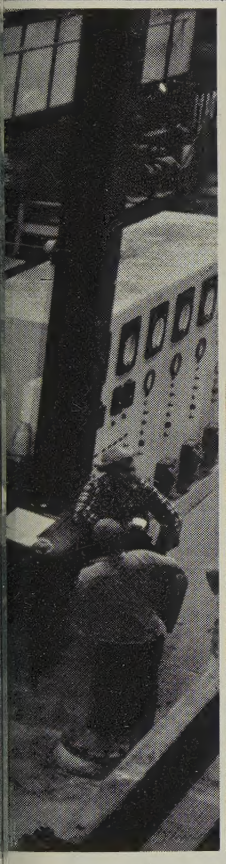

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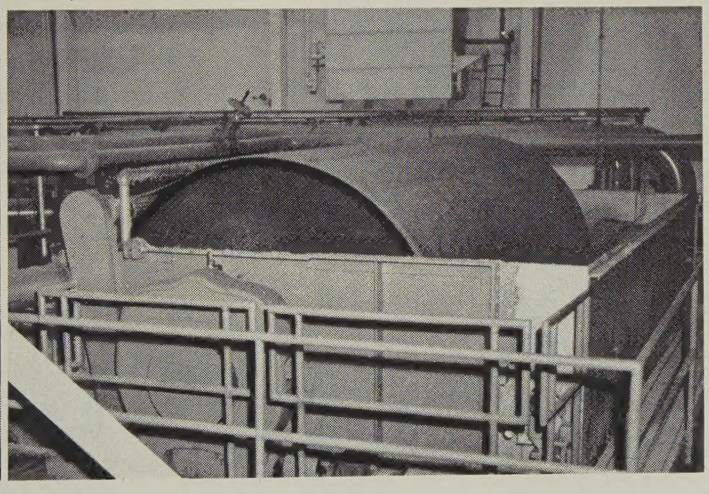

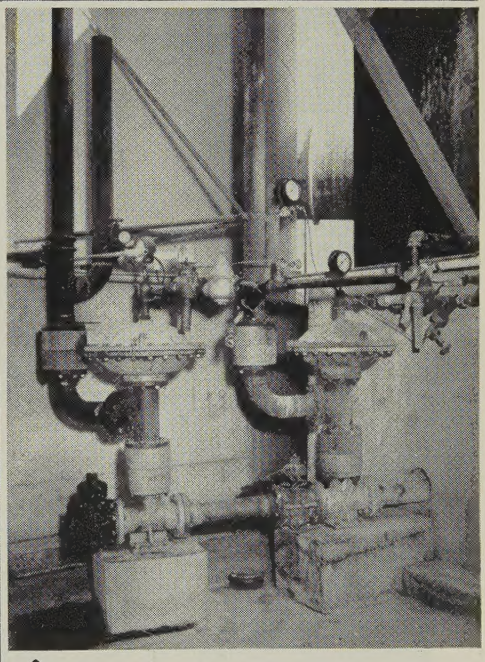

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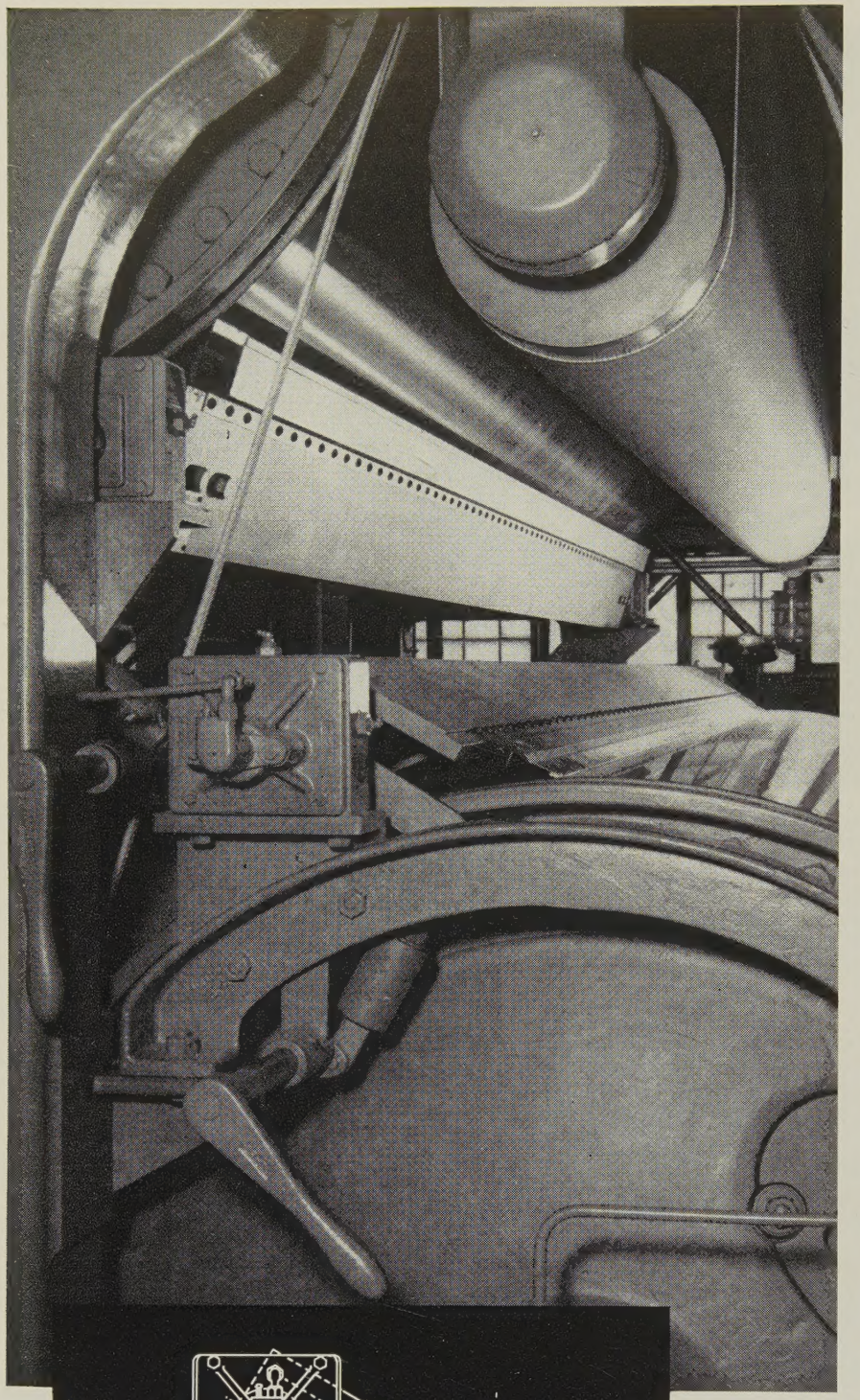

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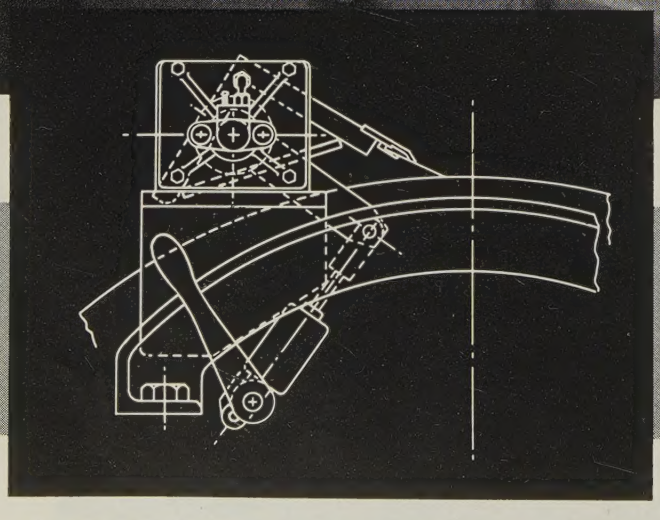

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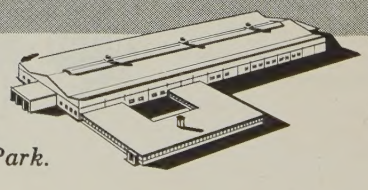

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PULP, PAPER, AND BOARD IN THE UNITED STATES

Review for 1958

Economic Review

W. LeRoy Neubrech

THE turn of the year brought numerous optimistic forecasts by industry executives and economists concerning the 1959 outlook for paper and board demand. The consensus appeared to range around an increase of 4 to 5% over 1958, which would result in establishing in 1959 an all-time high production record of about 32.0 to 32.5 million tons. This would be 2 to 3.5% over the previous record established in 1956. Some of the even higher expectations for 1959 may materialize as the year progresses.

The unreserved zeal of the industry in envisioning enlarged markets and a new high level of production in 1959 was not based merely upon wishful thinking. In addition to the favorable over-all economic outlook for business generally, the pulp, paper, and board industry has been particularly aggressive during the previous 2 or 3 years in plant modernization and operating efficiencies, technical research resulting in improved quality, and market research and development leading to new products, new applications, and product diversification. Carefully planned intensive selling and promotional programs also have been important factors in stimulating current sales.

Besides the major expansion in new paper and board manufacturing capacity in the United States, amounting to over 6 million tons between 1955 and 1958, additional new capacity of about 2.5 million tons is expected in the period 1959–61. Projected growing market requirements in the next 2 or 3 years point to the need for these facilities. However, any further noteworthy pulp, paper, or board capacity expansion in the United States or, for that matter, in the free world, scheduled for operation in this immediate 2 to 3 year period, should be very carefully appraised relative to production facilities in existence or already under construction versus estimated market requirements.

The trend toward vertical and horizontal integration apparent for several years continued through 1958. In a number of instances, integration through purchase or merger was made with other forest products industries, notably lumber and plywood. In many cases an important objective was to acquire commercial timberlands to meet long-range pulpwood needs. Companies producing a range of major forest products, including pulp, paper, and paperboard, are able to benefit from more efficient wood utilization. Waste wood from logging, sawmills, or other woodworking plants can be readily used for wood pulp chips or in various types of building boards. Thus, the industry generally has been alert to the growing importance of raw material supply and utilization as well as manufacturing and marketing efficiencies to meet the challenge of modern competition in 1959 and in future years.

The first 2 months of 1959 showed a strong resurgence in demand following the notable upturn evident in the last half of 1958. January and February, 1959, production ranged from 86 to 93% of capacity as historically measured by the major segments of the industry, compared with a range of 80 to 90% in those months last year. Furthermore, the capacity base this year is significantly higher than a year ago as the result of new production facilities placed in operation during 1958. Total production of paper and board in the first quarter of 1959 will probably exceed that of a year ago by a substantial margin. The trend of paper and board production was at a comparatively low level in the first 6 months of 1958, but showed an upturn in the last half, particularly in the closing months of the year. In 1957, the trend was generally downward during the year following the previous record output in 1956. For 1959, substantial tonnage and percentage gains are indicated during the first 6 months over the same period of 1958, with comparatively smaller gains in the last half.

The principal pulp and papermaking raw materials remained in adequate supply during 1958 but the upturn in demand and production of pulp, paper, and paperboard in the last 3 or 4 months of the year brought a notable strengthening in requirements, particularly for pulpwood and wastepaper. Many mills had reduced the level of their pulpwood inventories during 1957 and the first half of 1958 in line with the level of pulp production. The late 1958 and early 1959 upturn in pulpwood needs resulted in a firming of pulpwood prices, and moderate increases were reported in some areas of the country, according to U. S. Department of Commerce field office reports. At the same time, the surge in paperboard demand and production greatly increased requirements for wastepaper to meet higher production schedules and also to replenish relatively low mill inventories. As a consequence, wastepaper prices, as recorded by the Bureau of Labor Statistics, especially for the lower grades, advanced rapidly during late 1958 and remained at these higher levels during the early part of 1959.

Wood pulp prices, as reported by the Bureau of Labor Statistics, were unchanged during 1958, the last increase, a comparatively small one, having taken place in the fourth quarter of 1957.

In the area of paper and paperboard, the BLS price index data disclose only small price variations during 1958 and 1957. Paperboard prices remained substantially unchanged during this 2-year period. Paper

W. LEROY NEUBRECH, Assistant Director for Pulp, Paper, and Paperboard, Business and Defense Services Administration, U. S. Dept. of Commerce, Washington, D. C.
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prices, fluctuating slightly in different grades, showed only a small increase for 1958 over 1957.

Early this year, Commerce Department field offices and the trade press reported announcements of scattered small price advances by a few manufacturers. Many of the larger producing companies have announced that further increases in labor and raw materials costs this year may necessitate some advance in paper and paperboard prices.

Department field offices also report that paper and paperboard inventories in the hands of wholesale merchants, converters, and other types of consumers remain at low levels relative to sales volume, a situation which has prevailed since late 1957. It will be recalled that in the tight supply-demand situation for most grades of paper and paperboard which existed during 1955–56 there was evidence of substantial inventory accumulations, which were reduced during 1957 to more normal levels.

As of March, 1959, the majority of producers and consumers reporting to Commerce field offices stated that inventories of paper and board continue at relatively low levels, with customers placing more frequent rush orders and demanding prompt delivery. Most mill unfilled order files have increased substantially in recent weeks, and mills throughout the country are generally reported to have advanced from the 5 or 6 day per week operating schedules prevalent in 1958 to a 6 or 7 day operating schedule this year.

Both employment and earnings have benefited from the increased activity of the pulp, paper, and board industry during the past several months. With producing and converting mills operating longer hours or more days per week, it has been necessary to increase the number of production workers; and weekly earnings have been running higher partly as the result of higher hourly wage rates which became effective in the summer and fall of last year. Similarly, higher pulpwood demands have increased activity in pulpwood cutting and hauling to mills. Employment by paperstock dealers has also advanced.

The pulp, paper, board, and allied manufacturing industry ranks high in the industrial employment field. In 1958, the average number of production workers totaled 439,000, and total wages paid to productionworkers by the industry amounted to $2.0 billion. As the industry has grown, the need for production workers has increased materially as evidenced by the fact that 10 years before, in 1948, the industry employed 394,000 production workers with total wages amounting to $1.1 billion. These figures do not include the large number of workers engaged in forestry, plywood cutting, and transportation.

Further evidence of the tremendous growth in the pulp, paper, and board industry is the total value of sales, which in 1958 amounted to $11.0 billion compared with $6.1 billion in 1948. In 1939 total sales were valued at only $1.8 billion.

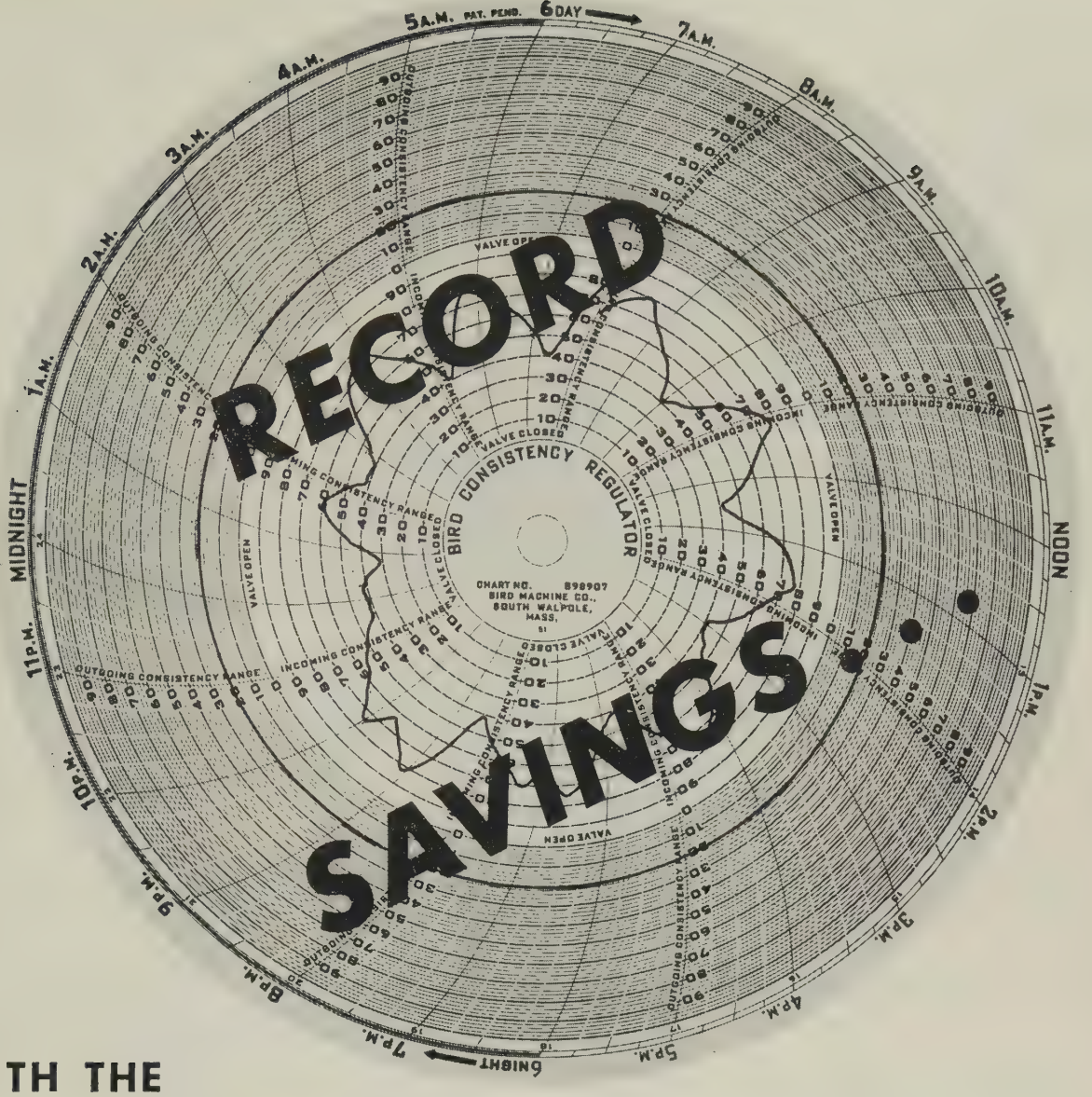
The growing diversification of uses of paper and paperboard has increased production and consumption of the products of the industry more rapidly than the average growth of the economy as measured by such indexes as the gross national product or the Federal Reserve Board index of industrial production. While paper has always been a basic material in the fields of printing and communication, which continue to grow in line with population and economic increases, the major tonnage growth in the past couple of decades has been in the area of packaging. The strong trend evident in the past several years in self-service retailing, particularly in foods and drugs, is now spreading to other retail merchandising outlets, such as department, hardware, and variety stores, and many others. Self-service invariably requires appropriate and attractive packaging which, for the most part, uses paper and paperboard. The numerous and varied uses of paper and board are also reflected in the continuous growth in other grade groups such as sanitary and tissue, fine papers, coarse and special industrial, and building papers and boards.

Summarizing the position of the industry in 1958, total production of paper and board amounted to 30.8 million tons, a gain of 0.4% over 1957. Pulpwood consumption amounted to 35.2 million tons, a decline of 1.2%. Wood pulp production at 21.7 million tons recorded a slight drop of 0.3%. Wastepaper consumption totaled 8.7 million tons, a gain of 2.1%. Because of slackened domestic market activity in the United States, as well as in many countries throughout the world, foreign trade in the products of the industry was at lower levels. Total exports of paper, paperboard,

Pulp, Paper, and Board Statistical High Lights

Item and unit	*1958*[a]	*1957*	*Per cent change*
Pulpwood, 1000 cords			
Receipts	34,273	35,969	−4.7
Consumption	35,229	35,662	−1.2
Inventories	5,930	6,731	−11.9
Wood pulp (total), 1000 short tons			
Production	21,734	21,800	−0.3
Imports	2,103	2,101	+0.1
Exports	515	622	−17.2
New supply[b]	23,322	23,279	+0.2
Consumption, total	23,347	23,341	Even
Paper and board	22,505	22,459	+0.2
Nonpaper	842	880	−4.3
Inventories	883	890	−0.8
Pulp, paper, and board mills	797	789	+1.0
Nonpaper mills	86	101	−14.9
Market wood pulp (at paper and board mills), 1000 short tons			
Receipts	2,499	2,668	−6.3
Consumption	2,530	2,758	−8.3
Inventories	357	388	−8.0
Market wood pulp (at nonpaper mills), 1000 short tons			
Receipts	828	875	−5.4
Consumption	842	880	−4.3
Inventories	86	101	−14.9
Wastepaper, 1000 short tons			
Receipts	8,613	8,475	+1.6
Consumption	8,670	8,493	+2.1
Inventories	466	523	−10.9
Paper and board production, total, 1000 short tons	30,797	30,678	+0.4
Paper	13,525	13,593	+0.5
Paperboard	14,151	14,060	+0.6
Wet machine	142	134	+6.0
Construction paper and board	2,979	2,891	+4.5

[a] Preliminary.
[b] New supply equals production plus imports minus exports.
Source: Prepared by the Forest Products Division, Business and Defense Services Administration, Department of Commerce, based on data from the Bureau of Census, Department of Commerce.



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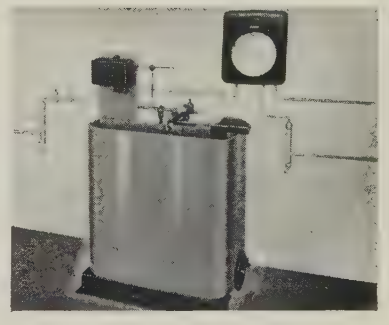

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Table I. Pulp, Paper, and Board High Lights, 1950–58

Item	Unit, millions of	1958	1957	1956	1955	1954	1953	1952	1951	1950
Pulpwood consumption	Cords	35.2	35.7	35.7	33.4	29.4	28.1	26.5	26.5	23.6
Wood pulp production	Tons	21.7	21.8	22.1	20.7	18.3	17.5	16.5	16.5	14.8
Wood pulp consumption[a]	Tons	22.5	22.5	23.0	21.5	19.0	18.7	17.3	17.7	16.5
Wastepaper consumption[a]	Tons	8.7	8.4	8.8	9.0	8.1	8.5	7.9	9.1	8.0
Paper and board production	Tons	30.8	30.7	31.4	30.1	26.9	26.6	24.4	26.0	24.4
Wood pulp imports	Tons	2.1	2.1	2.3	2.2	2.1	2.2	1.9	2.4	2.4
Newsprint imports	Tons	4.9	5.2	5.6	5.2	5.0	5.0	5.0	5.0	4.9

[a] In manufacture of paper and board only.
Source: Prepared by the Forest Products Division, Business and Defense Services Administration, based on data from the Bureau of the Census.

and paper products totaled 853,000 tons, a decline of 2% below 1957. Wood pulp exports declined to 515,000 tons, a drop of 17%. There were, however, some increases in specific items as outlined in another section of this report.

Imports of paper, paperboard, and products totaled 5.1 million tons, a drop of 7% below 1957. The principal volume item in imports, newsprint, accounted for 4.9 million tons in 1958, a decline of 338,000 tons or 6% from 1957. Imports of wood pulp, 2.1 million tons, showed no change from 1957.

5.1 million tons from the 1957 level of 5.5 million tons, nearly 95% of which are imports of newsprint from Canada.

Increases in imports for 1958 over 1957 occurred in 14 different items of paper products with total tonnage of 102,000 tons. Improvement ranged from 1 to 45% of these grades, with kraft wrapping (46,000 tons) the only volume item included, showing an increase of 37%.

Exports of paper, totaling 335,000 tons, dropped 11% over-all from the 1957 level. Total paperboard exports continued their annual increase, reaching a volume of

Table II. Total Value of Sales of the Pulp, Paper, Board, and Products Manufacturing Industry, 1939–58

Year	Millions of dollars	Year	Millions of dollars	Year	Millions of dollars	Year	Millions of dollars
1939	1785	1944	3629	1949	5468	1954	8,585
1940	2064	1945	3725	1950	6976	1955	9,891
1941	2836	1946	4469	1951	8439	1956	10,712
1942	2965	1947	5764	1952	7877	1957	10,765
1943	3389	1948	6060	1953	8381	1958[a]	10,983

[a] Preliminary.
Source: Office of Business Economics, Department of Commerce. Revised basis as shown in August, 1957, *Survey of Current Business*. The estimated dollar total of sales represents receipts of all operators of pulp, paper, paperboard, and product manufacturing companies. The figures include data for both corporate and noncorporate businesses, but are comparable to the sales data for corporations in *Statistics of Income* published by the Bureau of Internal Revenue.

Foreign Market Trends

Darwin DeGolia

United States foreign trade trends in pulp, paper, paperboard, and allied products varied greatly in 1958. Decreases from year earlier trade occurred in both imports and exports of the majority of the larger volume grades but many increases were evident in grades representing lesser tonnage.

Imports of pulpwood were 1.5 million cords in 1958, down 17% from 1957. Exports of 102,000 cords were 2% above 1957 shipments.

Wood pulp imports remained at the same level as those of 1957, but exports fell off by 17% to 515,000 tons, well below the high of 631,000 tons exported in 1955.

Paper and board imports during 1958 declined 6% to 362,000 tons in 1958, or 7.1% above those of 1957, marking a new high.

Exports of 15 grades and items of paper, board, and converted products increased over year earlier shipments. The largest volume item to show an increase was containerboard, 267,000 tons, with an increase of 5%.

Converted paper and board products, which include shipping sacks and paper bags, likewise continued a modest rise to a new record level in 1958 of 124,303 tons.

Darwin DeGolia, Foreign Trade Specialist, Business and Defense Services Administration, U. S. Dept. of Commerce, Washington, D. C.

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Aug. 17–21, 1959

Table III. Production Workers and Wages, Pulp, Paper, and Allied Products Industries, 1947–58

Year	Average number of wage earners (thousands)	Total dollar wages (millions)	Year	Average number of wage earners (thousands)	Total dollar wages (millions)	Year	Average number of wage earners (thousands)	Total dollar wages (millions)
1947	391	953	1951	420	1436	1955	453	1893
1948	394	1063	1952	422	1514	1956	463	2147
1949	382	1111	1953	442	1670	1957	467	2238
1950	404	1284	1954	439	1690	1958[a]	439	2027

[a] Preliminary.
Source: Prepared by Forest Products Division, BDSA. Based on data furnished by the Bureau of Labor Statistics, U. S. Department of Labor.

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Raw Material Trends

John R. Mutzabaugh

For the principal pulp, paper, and board raw materials, 1958 was a year of ample supplies, lowered consumer inventories, and divergent consumption trends. Consumption in the later months increased over year earlier use, a trend that had not been evident for some time but which now is expected to continue through 1959.

Pulpwood

Supplies of pulpwood were more than adequate throughout 1958. Deliveries in January in the North Central region were made at such an accelerated pace that acceptance had to be curtailed. Mild weather and readily available labor made possible earlier than usual cutting in the Northwest, assuring ample supplies for that area. Commerce Department field office reports indicate easy supply in the other regions during the year.

Requirementc hanges caused some innovations in normal supply procedure in the North Central region. A number of consumers altered their demand to include substantial quantities of broadleaf trees. As a result, local cutting of hardwoods increased and Canadian imports of coniferous species such as jack pine, spruce, and fir decreased. Total U.S. imports of pulpwood, mostly from Canada, dropped 17% from 1957 and receipts of imported hardwoods decreased 50%.

Lowered consumer inventories, principally for economy, were apparent in 1958 and are expected to continue. At the close of the year, pulp mill inventories of wood were 12% below December 1957, the largest drop, 25% occurring in the West. Field office reports indicate determined efforts by mills to increase economies, one of them being more careful stock control.

As an adjunct to the maintenance of lowered woodyard inventories and to further reduce operating costs, some North Central mills changed their method of handling incoming shipments. Now, as much wood as possible is moved from rail cars and trucks directly to the pulp mill conveyors in order to minimize double handling in the yard.

Over-all consumption of pulpwood dropped 1% from 1957, but most regions showed comparatively large increases in the use of hardwoods. Regional hardwood gains ranged from 1 to 12% and occurred in all areas except the South Central, where there was a decrease of 6%.

Fourth-quarter consumption rose to 9.4 million cords, the highest ever recorded for a 3-month period, and was 4% higher than in the same period of 1957, the first such increase in 1958.

This trend in increased consumption over year earlier use is expected to continue through 1959. Allowing forsome increase in use of other raw materials, pulpwood consumption should show a gain for 1959 over 1958 of about 4%, the same as expected for paper and board production.

Wood Pulp

Though supplies of wood pulp were adequate for the greater part

John R. Mutzabaugh, Industry Analyst, Business and Defense Services Administration, U. S. Dept. of Commerce, Washington, D. C.

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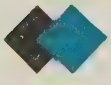

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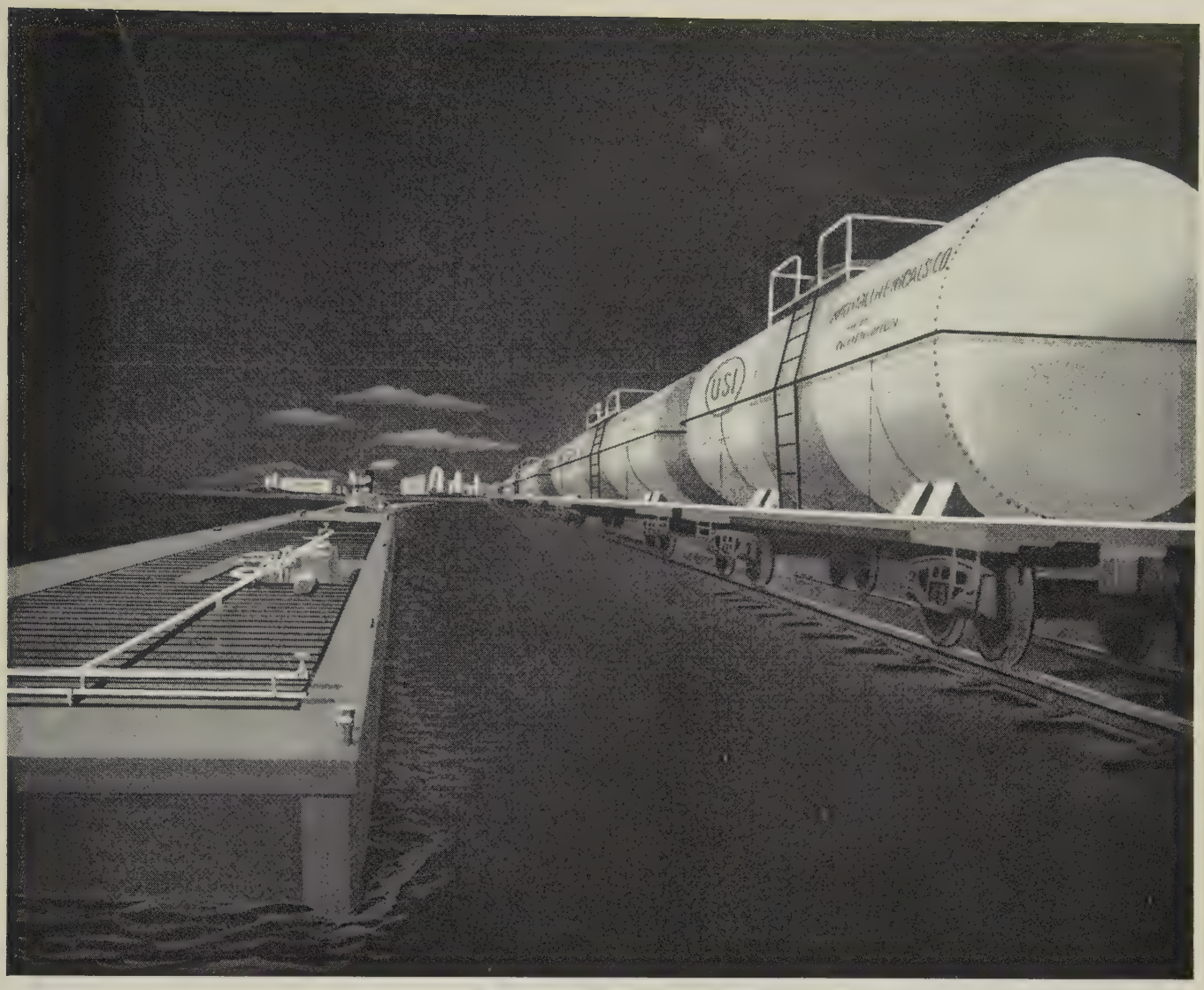

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of 1958, there was some evidence of press at integrated mills as the year ended. After being below year earlier consumption for the first 11 months of 1958, the use of purchased pulp at integrated mills increased 5% in December over the final month of 1957.

Further indication of tightening supply as the year closed was shown in the large increase of imports from overseas. Following a decrease of 5% from year earlier receipts for the first 9 months of 1958, imports of wood pulp from overseas sources in the last quarter rose 33%

Table IV. Total United States Imports and Exports Paper Base Stocks, Paper and Manufactures, 1939–58

(In millions of dollars)

Year	Imports	Exports	Year	Imports	Exports	Year	Imports	Exports
1939	215	40	1949	666	113	1954	926	228
1945	298	102	1950	746	107	1955	979	291
1946	419	116	1951	958	231	1956	1092	288
1947	657	173	1952	925	193	1957	1035	324
1948	754	139	1953	933	153	1958[a]	1036	304

[a] Preliminary.
Source: See Table I.

Table V. Pulpwood—United States Annual Receipts, Imports, Consumption, and Inventories, 1949–58

(1000 standard cords—roughwood basis)

Item	1958[a]	1957	1956	1955	1954	1953	1952	1951	1950	1949
Receipts, total[b]	34,273	35,969	37,176	32,879	28,597	27,867	27,375	27,778	22,546	19,266
Domestic[b]	32,839	34,135	25,202	30,948	26,972	26,319	25,065	25,128	20,712	17,619
Imported	1,434	1,834	1,974	1,931	1,625	1,548	2,310	2,650	1,834	1,647
Northeast, total	3,854	4,693	5,031	4,527						
Domestic	3,217	3,797	4,003	3,601						
Imported	637	896	1,028	926						
North Central, total	3,342	3,642	3,711	3,146						
Domestic	2,932	3,140	3,262	2,672						
Imported	410	502	449	474	(c)					
South Atlantic, total (domestic only)	11,815	11,873	12,224	11,074						
South Central, total (domestic only)	8,463	8,150	8,358	7,634						
West, total[b]	6,799	7,611	7,852	6,498						
Domestic[b]	6,412	7,175	7,355	5,967						
Imported	387	436	497	531						
Consumption, total[b]	35,229	35,662	35,749	33,356	29,436	28,140	26,476	26,522	23,627	19,945
Northeast	4,354	4,662	4,823	4,491						
North Central	3,468	3,405	3,528	3,354						
South Atlantic	11,844	12,052	12,006	11,231	(c)					
South Central	8,386	8,256	8,197	7,796						
West[b]	7,177	7,287	7,201	6,484						
Inventories, total[b]	5,930	6,731	6,228	4,777	5,070	5,639	5,929	5,072	3,815	4,950
Northeast	1,577	1,981	1,688	1,467						
North Central	1,548	1,695	1,407	1,223						
South Atlantic	720	637	786	546	(c)					
South Central	584	418	539	375						
West[b]	1,501	2,000	1,808	1,166						

[a] Preliminary.
[b] Beginning with January, 1955, figures have included data for operations in Alaska.
[c] Beginning in January, 1955, the geographic regions used by the Bureau of the Census to present pulpwood data are those generally employed by Census in presenting economic statistics and are not the pulpwood regions used previously. For 1944–54 regional data on previous basis, see March 1955—annual review "Pulp, Paper and Board Industry Report."
Source: See Table I.

Table VI. Total United States Annual Wood Pulp Imports All Grades—by Major Countries of Origin, 1949–58

(1000 short tons)

Country	1958[a]	1957	1956	1955	1954	1953	1952	1951	1950	1949
Total	2103	2101	2332	2214	2050	2158	1937	2361	2385	1763
Canada	1821	1835	1955	1865	1678	1614	1578	1877	1717	1314
Sweden	175	163	214	190	224	336	190	258	398	266
Finland	76	97	153	145	133	160	145	183	206	149
Norway	29	6	9	14	15	37	21	36	29	29
All other	2	..	1	[b]	..	11	3	7	35	5

[a] Preliminary.
[b] Less than 1000 short tons.
Source: See Table I.

Table VII. Total United States Annual Wood Pulp Exports All Grades—by Geographical Area, 1950–58

(1000 short tons)

Area	1958[a]	1957	1956	1955	1954	1953	1952	1951	1950
Total	515	622	525	631	442	162	212	202	96
Canada and Newfoundland	52	64	62	58	48	38	37	40	37
United Kingdom	132	166	156	204	108	31	41	36	11
Other Europe	172	160	117	161	107	22	45	63	20
Latin America	100	101	100	146	128	47	64	48	22
Asia, Africa, and Oceania	59	131	90	62	51	24	25	15	6

[a] Preliminary.
Source: See Table I.

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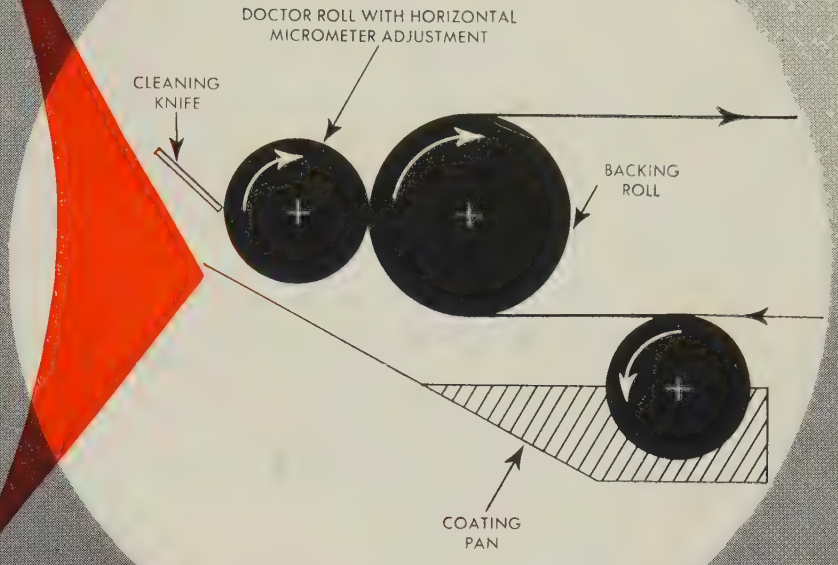

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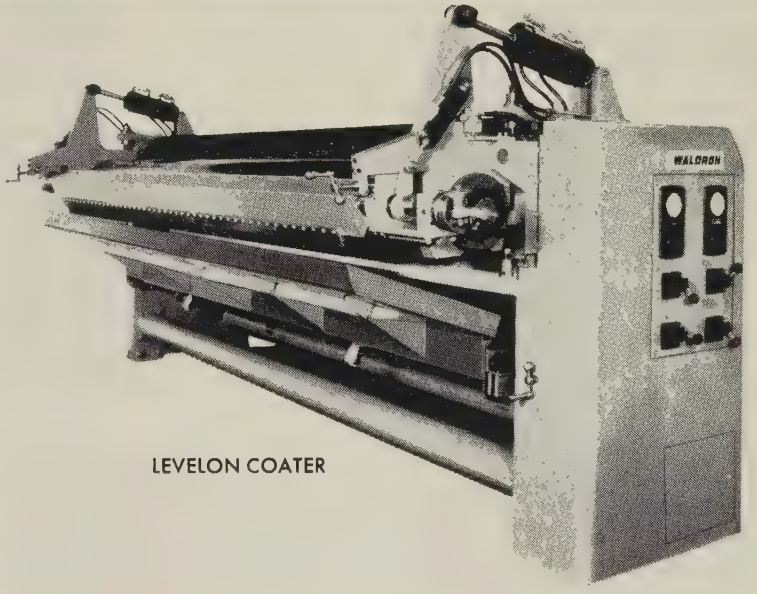

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over the same period in 1957. Total imports of wood pulp for the year, of which 87% originated in Canada, were about even with 1957.

Consumer inventories of market pulp at the year's end were 9% below December, 1957. Stocks of purchased pulp at paper and board mills were down 8% and at nonpaper mills down 15%. Because of large pulp mill inventories, total stocks of wood pulp were down only 1% at the end of December, 1958, from the same month of 1957.

Total consumption of wood pulp at paper and board mills remained about the same as in 1957 but there was considerable divergency in the trends of individual grades. Use of bleached sulphate increased 9% over 1957 as did defibrated or exploded. Consumption of the other grades dropped an average of 2%.

The 5% increase in the use of purchased pulp at integrated mills in December, noted previously as a factor in supply, may be a brief respite or the reversal of a consumption trend that has been prevalent in recent years. Consumption of purchased pulp at integrated and partially integrated mills represented 46% of market pulp demand in 1956 and dropped to 41% in 1958. Use of purchased pulp at integrated mills was up 4% for January, 1959, over the same month of 1958.

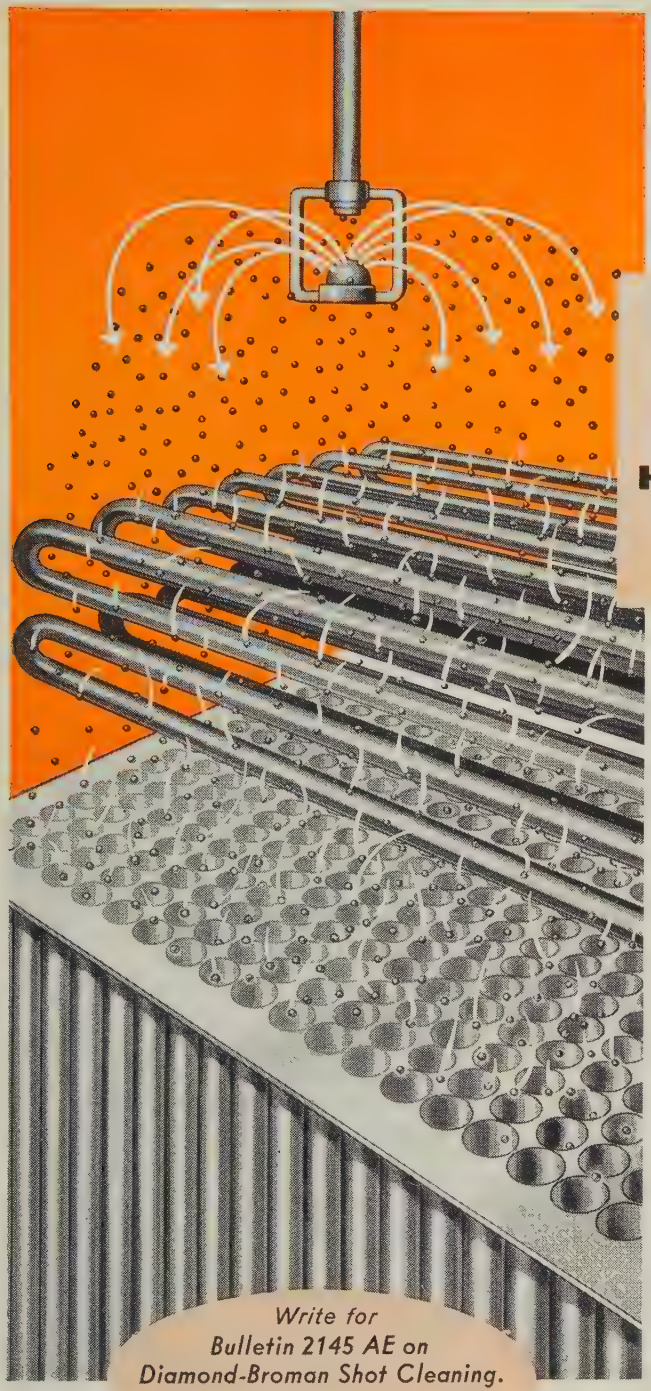
Consumption of market pulp at nonpaper plants was 4% below 1957. As the textile industry, a major consumer of rayon and acetate fiber made from dissolving wood pulp, is expected to show little increase in output for this year over 1958, it is unlikely that any great increase in the demand for market pulp in nonpaper use will occur.

The trend in consumption of wood pulp in 1959 is expected to be upward, in line generally with the anticipated increase of 4% for paper and board production, but with some variation possible depending principally on the extent of wastepaper use.

Wastepaper

Supplies of nearly all grades of wastepaper were plentiful through 1958. Some tightening was apparent as the year ended but the only acute shortage reported by department field offices was in the supply of "old news."

Diamond SHOT CLEANING SYSTEM



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Diamond gives you better boiler cleaning at lower cost.

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REHEATERS

Shot cascading over horizontal tubular surfaces and through vertical air heater tubes, does an excellent job of removing soot and ash deposits from difficult-to-clean surfaces and those which foul rapidly.

Shot Cleaning has proved itself in more than 30 installations in the United States and in more than 800 installations in Europe. Many installations represent exceptionally difficult cleaning problems such as tubular air heaters, economizers and superheaters in black liquor fired boilers in paper mills. In a large central station, the system is now keeping air heaters clean which previously had to be water washed approximately every eight months, each washing requiring a three day boiler outage. With Diamond Shot Cleaning, draft losses are uniformly low and water washing has been eliminated entirely.

Shot is spread by distributors and cascades over tube surfaces ricocheting from tube to tube, or from side to side of internal surfaces of vertical air heater tubes. Much of the ash removed is carried off by flue gas. Heavier particles fall into the shot hopper and recirculate with the shot until broken fine enough to pass out with the gases. Shot accumulated in the hopper is lifted pneumatically to the storage area and reused continuously. Areas which foul rapidly can be kept completely clean by increasing the length of the shot cycle (it can be continuous) without disturbing boiler operation.

Over a period of years Diamond has conducted extensive research in shot cleaning, as a part of our half century policy of providing the best in boiler cleaning. To supplement this program, Diamond acquired U.S. rights to the Broman-Ekstrom system used in Europe.

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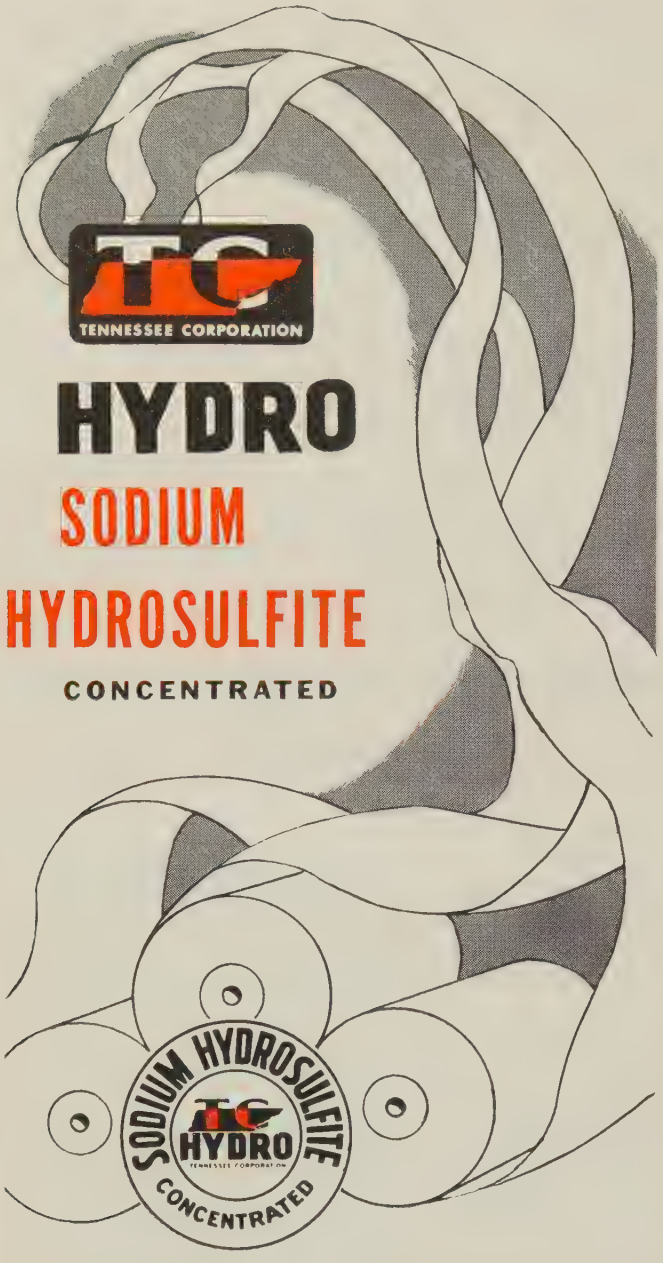

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Though for different reasons, shortages of old news were reported in both the New York and Chicago areas during the fourth quarter. The newspaper strike in December was given as the reason for the New York shortage, and severe weather which prevented normal collections was reported as the cause of short supply in the Chicago area.

Consumer inventories at the end of the year were 466,000 tons, slightly more than 3 weeks' supply and 11% below December, 1957. Favorable weather and larger available supplies of old news will probably result in higher consumer stocks.

Consumption of wastepaper in 1958 was up 2% over 1957 and also accounted for a larger percentage of total raw material consumption than it had for several years. Total wastepaper consumption for the year of 8.7 million tons represented 26.9% of all raw materials used in the production of paper and board, the highest proportionate use since 1955.

The trend of increase over year earlier consumption coupled with higher proportionate use may enable waste paper to attain a larger percentage of increase in consumption for 1959 over 1958 than the 4% expected for other raw materials.

Paper and Board Trends

John J. Bartosiewicz

Paper and board production, an important barometer of American economic growth, signaled the end of the general economic recession in 1958 by the setting of new monthly records at year's-end, giving substance to authoritative forecasts for a better year in 1959. In retrospect, the year 1958 was one of troubling excess capacity, lowered imports and exports, decreasing expenditures for new plants and equipment, leveling of tonnage production at the 1957 figure, and moderately rising dollar sales by both manufacturers and merchant wholesalers to new record levels.

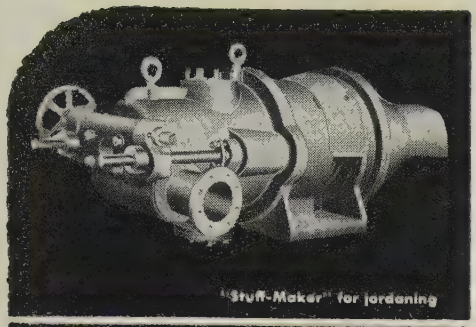
Production

The paper and board industries staged a dynamic recovery in the last 4 months of 1958 to offset the effects of the general business slowdown in the earlier months of the year. In September, October, November, and December the industries established new monthly records for paper and board production, exceeding previous monthly highs by 5, 4, 1, and 2%, respectively.

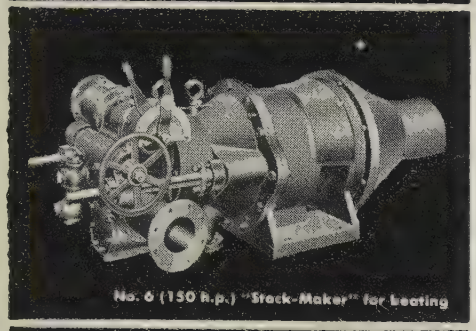
The upsurge of activity in the closing months of 1958 is showing no sign of losing impetus in 1959. January, 1959, paper and board production at 2.7 million tons is more than 2% above the earlier record set in January, 1957, and early reports on February indicate a continuing strong demand.

Paper and board production during 1958 at 30.8 million tons was slightly above the 1957 output of 30.7 million tons and 2% below the record 1956 production of 31.4 million tons when producton exceeded demand. While total 1958 paper and board production showed little change from 1957, the following major grades posted increases of about 4% over 1957: Fine, sanitary tissue, special food board, and construction

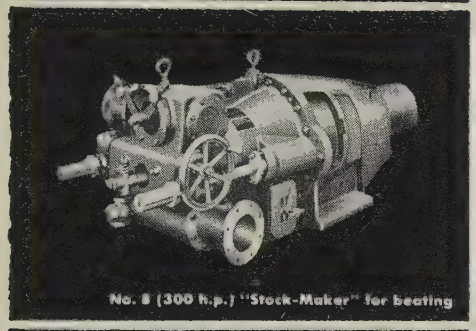
John J. Bartosiewicz, Program Executive for Paperboard, Business and Defense Services Administration, U. S. Dept. of Commerce, Washington, D. C.



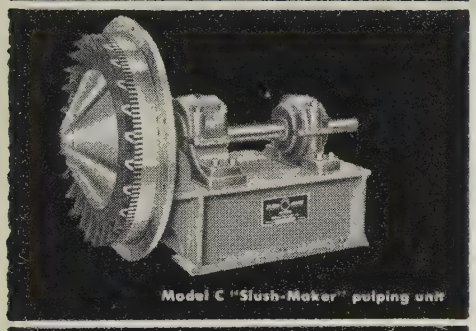
"Stuff-Maker" for jordaning



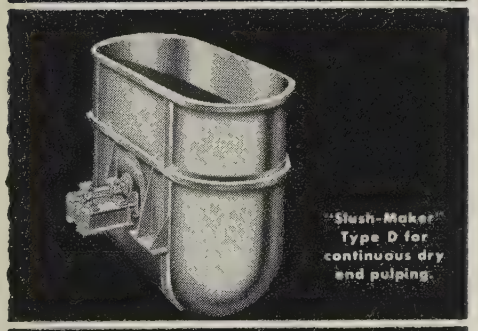
No. 6 (150 h.p.) "Stock-Maker" for beating



No. 8 (300 h.p.) "Stock-Maker" for beating



Model C "Slush-Maker" pulping unit



"Slush-Maker" Type D for continuous dry end pulping.

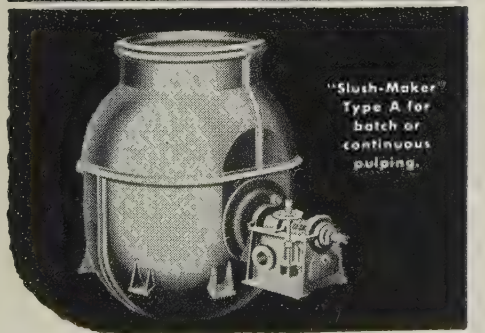


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Table VIII. Wood Pulp—Year-End Inventories, Pulp, Paper, and Board Mills Only, 1949–58

(1000 short tons)

Item	1958[a]	1957	1956	1955	1954	1953	1952	1951	1950	1949
Wood pulp, total	797	789	806	691	675	655	711	611	492	512
Special alpha and dissolving	73	79	82	66	63	54	63	24	15	29
Sulphite, total	217	247	239	244	216	228	256	239	193	238
Bleached	155	174	145	158	125	115	120	112	86	100
Unbleached	62	73	94	86	91	113	136	127	107	138
Sulphate, total	434	383	399	300	305	288	298	231	197	147
Bleached	285	260	235	180	190	178	166	114	108	69
Semibleached	26	23	27	22	16	15	11	8	5	5
Unbleached	123	100	137	98	99	95	121	110	84	73
Soda	14	18	20	20	16	17	16	16	11	15
Groundwood	39	38	45	44	53	53	63	85	70	65
Miscellaneous	20	24	21	17	22	15	15	17	7	17

[a] Preliminary.
Source: See Table I.

Table IX. Wood Pulp—United States Annual Production and Domestic Consumption in Paper and Board Manufacture, 1949–58

(1000 short tons)

Item	1958[a]	1957	1956	1955	1954	1953	1952	1951	1950	1949
Production, total	21,734	21,800	22,131	20,740	18,256	17,537	16,473	16,524	14,849	12,207
Special alpha and dissolving	933	1,011	941	983	760	677	706	616	479	374
Sulphite, total	2,380	2,575	2,686	2,555	2,383	2,323	2,365	2,525	2,370	2,162
Bleached	1,850	1,957	2,002	1,909	1,795	1,729	1,692	1,761	1,629	1,455
Unbleached	530	618	684	646	588	594	673	764	741	707
Sulphate, total	12,283	11,935	12,131	11,289	9,812	9,445	8,569	8,572	7,502	5,977
Bleached	3,982	3,721	3,659	3,202	2,683	2,389	2,083	1,899	1,433	1,118
Semibleached	629	563	488	423	329	303	275	294	360	264
Unbleached	7,672	7,651	7,984	7,664	6,800	6,753	6,211	6,379	5,709	4,595
Soda	427	428	479	440	430	427	425	446	522	492
Groundwood	2,919	3,089	3,041	2,729	2,485	2,343	2,380	2,474	2,216	1,961
Defibrated, exploded, etc.	1,146	1,059	1,171	1,408	1,198	1,153	1,059	945	935	604
Semichemical	1,548	1,583	1,547	1,190	1,028	1,029	829	797	686	506
Screenings, damaged, etc.	98	120	135	146	160	140	140	150	140	130
Consumption, total	22,505	22,459	22,998	21,454	19,034	18,684	17,286	17,737	16,509	13,636
Special alpha and dissolving	61	71	81	76	59	56	71	52	40	26
Sulphite, total	3,010	3,170	3,397	3,229	2,955	3,012	2,971	3,240	3,276	2,986
Bleached	2,241	2,268	2,387	2,274	2,062	2,070	1,944	2,037	2,209	1,825
Unbleached	769	902	1,010	955	893	942	1,027	1,203	1,247	1,161
Sulphate, total	13,102	12,767	12,880	11,999	10,426	10,294	9,136	9,310	8,381	6,678
Bleached	4,590	4,184	4,100	3,364	3,148	2,904	2,500	2,383	1,862	1,484
Semibleached	672	654	554	486	363	354	308	330	389	277
Unbleached	7,840	7,929	8,226	7,879	6,915	7,036	6,328	6,597	6,130	4,916
Soda	466	480	530	491	496	485	461	484	559	526
Groundwood	3,053	3,215	3,231	2,935	2,634	2,528	2,610	2,752	2,483	2,184
Defibrated, exploded, etc.	1,146	1,054	1,165	1,407	1,191	1,142	1,064	944	932	602
Semichemical	1,552	1,576	1,571	1,179	1,121	1,022	828	797	685	502
Screenings, damaged, etc.	115	126	143	138	152	145	144	159	153	131

[a] Preliminary.
Source: See Table I.

Table X. Wood Pulp in Other Than Paper and Board Manufacture, 1952–58

(1000 short tons)

	1958[a]	1957	1956	1955	1954	1953	1952
Receipts, total	828	875	799	845	763	770	783
Special alpha and dissolving	719	760	686	740	663	687	705
All other	109	115	113	105	100	83	78
Domestic, total	554	572	507	561	519	544	560
Special alpha and dissolving	482	496	435	491	451	485	502
All other	72	76	72	70	68	59	58
Imports from Canada,[b] total	273	303	291	284	244	226	223
Special alpha and dissolving	238	263	251	249	213	202	203
All other	35	40	40	35	31	24	20
Consumption, total	842	880	796	825	762	799	755
Special alpha and dissolving	732	766	685	721	661	713	676
All other	110	114	111	104	101	86	79
Inventories, year-end, total	86	101	105	104	85	83	106
Special alpha and dissolving	78	92	96	96	78	77	101
All other	8	8	9	8	7	6	5

[a] Preliminary.
[b] Includes a small quantity from overseas.
Source: See Table I.

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board. Newsprint and special industrial grades declined 4 and 7%, respectively.

Newsprint Consumption

Estimated newsprint consumption in the United States during 1958, at 6.5 million tons, was 4% under the estimated 1957 total of 6.8 million tons. The decline in newspaper advertising and strikes against newspaper publishers were partly responsible for the decrease.

Early 1959 Outlook

Department of Commerce field office reports, based on interviews with most of the largest paper and board companies, indicate that first-quarter activity will equal or slightly exceed the record fourth quarter of 1958, with even more improvement expected in the second quarter of 1959. Customers for paper and board products seem to have adopted a "wait and see" attitude in buying for stock replenishment. In their favor has been the ability of paper and board mills to make prompt delivery on rush orders.

Capacity

In 1958, the paper and paperboard industries operated at the lowest production-capacity ratios in several years, paper averaging 87.1 and paperboard 86.0. The lower ratios resulted from substantial increases, almost 2 million tons, in capacity in 1958 as the actual tonnage output equaled that of 1957 when the ratio for paper

Table XI. Other Fibrous Materials—United States Annual Receipts, Consumption, and Inventories, 1949–58

(1000 short tons)

Item	*1958*[a]	*1957*	*1956*	*1955*	*1954*	*1953*	*1952*	*1951*	*1950*	*1949*
Receipts, total	9631	9572	10,146	10,405	9204	9769	9045	10,715	9399	7759
Wastepaper	8613	8475	8,914	9,037	8029	8427	7815	9,252	7964	6522
Other (straw, rags, bagasse, etc.)	1018	1097	1,232	1,368	1175	1342	1230	1,463	1435	1237
Consumption, total	9712	9599	10,090	10,381	9276	9786	9092	10,528	9395	7815
Wastepaper	8670	8493	8,836	9,041	8064	8531	7881	9,071	7956	6600
Other (straw, rags, bagasse, etc.)	1042	1106	1,254	1,340	1212	1255	1211	1,457	1439	1215
Inventories, total	973	1054	1,081	1,035	1014	1082	1095	1,163	966	998
Wastepaper	466	523	541	456	454	479	522	589	387	397
Other (straw, rags, bagasse, etc.)	507	531	540	579	560	603	573	574	579	601

[a] Preliminary.
Source: See Table I.

Table XII. Market Wood Pulp[a]—Paper and Paperboard Mills Only—Annual Receipts, Consumption, and Inventories, 1949–58

(1000 short tons)

Item	*1958*[b]	*1957*	*1956*	*1955*	*1954*	*1953*	*1952*	*1951*	*1950*	*1949*
Wood pulp, total all grades:										
Receipts, total	2499	2668	3018	2933	2447	2490	2276	2819	2916	2152
Domestic	1111	1328	1654	1579	1226	1155	1120	1297	1213	938
Imported	1388	1340	1364	1354	1221	1335	1156	1522	1703	1214
Canada	1110	1060	1011	1000	840	819	846	1054	976	707
European	278	280	353	354	381	516	310	468	727	507
Consumption (purchased pulp) total	2530	2758	2972	2886	2422	2500	2252	2742	2902	2325
Inventories (purchased pulp) total	357	388	478	466	395	380	404	395	332	342
Sulphite, all grades										
Receipts, total	986	1116	1217	1226	1035	1107	1139	1398	1466	1209
Domestic	430	561	660	667	534	563	595	702	672	588
Imported	556	555	557	559	501	544	544	696	794	621
Canada	444	459	452	454	365	336	402	498	480	370
European	112	96	105	105	136	208	142	198	314	251
Consumption, total	1012	1144	1213	1208	1039	1147	1112	1362	1484	1313
Inventories, total	137	163	191	212	169	179	213	202	163	194
Sulphate, bleached and semibleached										
Receipts, total	950	942	1030	952	704	650	496	447	443	312
Domestic	418	507	660	568	360	316	246	189	197	119
Imported	532	435	370	384	344	334	250	258	246	193
Canada	449	354	282	290	251	221	183	172	144	120
European	83	81	88	94	93	113	67	86	102	73
Consumption, total	954	968	1023	953	697	662	483	438	433	310
Inventories, total	122	126	152	129	107	95	68	60	51	40
Sulphate, unbleached										
Receipts, total	275	306	389	397	361	379	280	500	562	302
Domestic	89	117	131	154	148	129	106	209	128	68
Imported	186	189	258	243	213	250	174	291	434	234
Canada	123	106	140	131	102	112	98	146	165	88
European	63	83	118	112	111	138	76	145	269	146
Consumption	277	332	356	368	349	341	284	481	543	356
Inventories	64	66	92	78	73	69	72	81	69	62
Groundwood and other grades:										
Receipts, total	288	304	382	358	347	354	361	474	445	329
Domestic	174	143	203	190	184	147	173	197	216	163
Imported	114	161	179	168	163	207	188	277	229	166
Canada	94	141	137	125	122	150	163	238	187	129
European	20	20	42	43	41	57	25	39	42	37
Consumption, total	287	314	380	357	337	350	373	461	442	346
Inventories, total	34	33	43	47	46	37	51	52	49	46

[a] Market pulp consists of domestic or imported pulp purchased from a mill not under the same ownership control as the purchaser.
[b] Preliminary.
Source: Data on receipts of market pulp have been calculated by Forest Products Division, BDSA, as data published by the Bureau of the Census, no longer include such information. Other data, see Table I.

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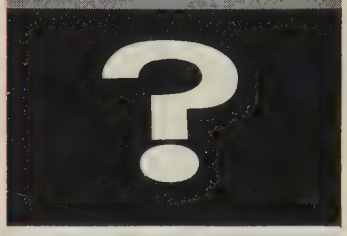

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Table XIII. Paper and Paperboard—United States Production, 1949–58

(1000 short tons)

	1958[a]	1957	1956	1955	1954	1953	1952	1951	1950	1949
All types	30,797	30,678	31,441	30,154	26,876	26,605	24,423	26,048	24,375	20,316
Paper, total	13,525	13,593	13,990	12,897	11,649	11,368	10,899	11,625	10,639	9,198
Newsprint	1,723	1,797	1,620	1,459	1,202	1,069	1,109	1,108	1,013	918
Groundwood	830	855	972	886	788	771	806	791	705	674
Printing	662	684	781	706	613	600	589	519	488	484
Converting	123	128	153	142	146	143	170	220	187	162
Other	45	43	38	38	29	28	47	52	30	28
Machine coated paper	1,559	1,537	1,512	1,312	1,222	1,182	1,096	1,113	1,020	887
Coated, one side	117	103	117	128	121	100	80	89	68	93
Coated, two sides	1,442	1,434	1,395	1,184	1,101	1,082	1,016	1,024	952	794
Book paper	1,642	1,659	1,820	1,739	1,577	1,603	1,482	1,610	1,579	1,416
General printing	970	968	1,089	1,047	964	1,000	959	1,034	1,008	926
Converting	651	680	716	679	602	593	513	558	557	476
Other	21	11	15	13	11	10	10	18	14	14
Fine paper	1,568	1,511	1,575	1,450	1,285	1,299	1,295	1,366	1,199	1,015
Writing paper	1,212	1,178	1,225	1,136	1,007	1,034	1,051	1,093	958	806
Rag	113	118	123	126	121	131	132	161	138	120
Chemical	1,099	1,060	1,102	1,010	886	903	919	932	820	686
Bristols	125	115	129	119	106	107	107	109	100	80
Cover and text	115	104	108	95	83	70	61	69	65	65
Thin paper	116	114	113	100	89	88	76	95	76	64
Coarse paper	3,631	3,663	3,948	3,680	3,462	3,385	3,238	3,626	3,298	2,758
Kraft paper	2,616	2,676	2,910	2,712	2,554	2,578	2,366	2,624	2,381	1,994
Wrapping	299	355	430	406	402	429	361	379	393	380
Shipping sack	758	830	803	796	749	668	716	806	704	481
Bag	1,006	929	1,045	893	863	895	749	790	716	656
Other converting	553	562	632	617	540	586	540	649	568	477
Glassine, greaseproof and vegetable parchment	175	168	176	164	154	149	138	178	162	141
Other coarse paper	840	819	862	796	746	662	734	824	755	623
Wrapping	237	236	258	260	262	211	291	326	320	311
Shipping sack	53	48	49	40	34	43	37	44	43	29
Bag	88	86	88	86	65	49	46	48	38	35
Other converting	462	449	467	410	385	359	360	406	354	248
Special industrial paper including absorbent paper	611	659	683	610	501	554	516	538	460	335
Sanitary paper	1,734	1,666	1,621	1,521	1,386	1,274	1,148	1,244	1,148	1,008
Toweling	404	412	382	353	319	297	275	290	264	233
Toilet tissue	793	776	774	734	659	607	540	600	542	484
Napkin	220	194	199	187	171	149	140	136	143	112
Facial tissue	239	233	218	203	195	180	150	168	157	143
Other sanitary	178	51	48	44	42	41	43	50	42	36
Tissue paper except sanitary and thin	227	246	239	240	226	231	209	229	217	187
Paperboard, total	14,151	14,060[b]	14,234[b]	13,869	12,190	12,336	10,771	11,620	10,925	8,997
Container board	7,658	7,629	7,763	7,552	6,488	6,653	5,766	6,323	5,830	4,680
Liners	5,214	5,177	5,231	5,111	4,394	4,451	3,902	4,213	3,872	3,132
Corrugating	2,223	2,227	2,282	2,191	1,872	1,906	1,583	1,784	1,637	1,305
Container chipboard	221	225	250	250	222	296	281	326	321	243
Bending board	4,242	4,149	4,112	3,931	3,580	3,544	3,147	3,271	3,129	2,613
Folding boxboard	2,501	2,632	2,611	2,592	2,440	2,445	2,193	2,361	2,352	1,943
Special food board	1,330	1,281	1,290	1,156	1,001	954	799	772	655	516
Other bending board	411	236	211	183	139	145	155	138	122	154
Nonbending board	1,013	1,036	1,048	1,053	923	958	786	877	877	748
Setup boxboard	731	775	794	797	718	747	687	733	712	617
Other nonbending	282	261	254	256	205	211	99	144	165	131
Special paperboard	1,125	1,148	1,211	1,247	1,113	1,106	1,009	1,064	1,002	873
Cardboard	113	84	85	86	86	75	69	85	87	83
Wet machine board	142	134	147	179	136	156	140	148	166	131
Construction paper and board	2,979	2,891	3,070	3,209	2,901	2,745	2,607	2,655	2,645	1,990
Construction paper	1,349	1,328	1,428	1,586	1,428	1,371	1,298	1,386	1,425	1,155
Construction board	1,630	1,563	1,642	1,622	1,473	1,374	1,309	1,269	1,220	839

[a] Preliminary.
Source: See Table I.

Table XIV. Production of Newsprint in North America, 1939–58

(1000 short tons)

Year	Total	United States	Canada	Year	Total	United States	Canada	Year	Total	United States	Canada
1958[a]	7819	1723	6096	1951	6624	1108	5516	1944	3985	721	3264
1957	8200	1804	6396	1950	6292	1013	5279	1943	4030	811	3219
1956	8084	1615	6469	1949	6092	918	5174	1942	4422	967	3455
1955	7650	1459	6191	1948	5859	876	4983	1941	4815	1044	3771
1954	7186	1202	5984	1947	5653	833	4820	1940	4826	1056	3770
1953	6790	1069	5721	1946	5279	773	4506	1939	4129	954	3175
1952	6796	1109	5687	1945	4317	725	3592				

[a] Preliminary.
[b] New supply equals production plus imports minus exports.

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was 90.9 and for paperboard 90.0. The effect was to increase unit operating costs. However, indicating optimism in the long-range future, the industries are expected to add slightly more than 1 million tons of capacity during 1959. The U. S. Department of Commerce report, "Pulp, Paper and Board Supply-Demand," projects required U. S. production in 1965 at 43.8 million tons, an increase of about 42% above the 1958 level of 30.8 million tons.

Manufacturers' Sales and Inventories

Manufacturers' sales of pulp, paper, board, and products reached an all-time high of $11 billion during 1958, $218 million over the 1957 total. The 2% increase in sales was partly attributable to moderate price increases, as the gain in physical volume was negligible. Year-end inventories remained relatively unchanged at $1443 million from December, 1957.

Wholesale Sales and Inventories

Sales by paper merchant wholesalers reached a record high in 1958 of $3.3 billion, an increase of 3% above 1957 and 1956. According to the Bureau of the Census survey on wholesale sales and inventories, the value of inventories at the end of December, 1958, were slightly higher than a year previous, but the December, 1958, ratio of stock to sales decreased substantially from December, 1957.

Expenditures for New Plants and New Equipment

Expenditures by paper and allied products industries for new plants and equipment during 1958 are estimated at $578 million, a drop of 29% from the 1957 level of $811 million, according to the latest survey conducted jointly by the Securities and Exchange Commission and the Department of Commerce. Based on recent reports of anticipated expenditures in 1959, the

Table XV. Newsprint—United States Production, Imports, Exports, Domestic Consumption and Inventories, 1949–58

(1000 short tons)

Item	1958[a]	1957	1956	1955	1954	1953	1952	1951	1950	1949
Production	1723	1797	1620	1458	1202	1069	1109	1108	1013	918
Imports	4883	5221	5569	5159	4992	5004	5033	4963	4863	4639
Exports	127	174	152	207	140	47	105	71	44	39
Total supply	6479	6844	7037	6410	6054	6026	6037	6000	5832	5518
Inventories, total	878	900	827	597	671	720	803	681	553	584
Publishers	851	881	817	589	665	712	791	673	545	573
Mill	27	19	10	8	6	8	12	8	8	11
Change in stocks	−22	+73	+230	−74	−49	−83	+122	+128	−31	−14
Apparent consumption	6501	6771	6807	6484	6103	6109	5915	5872	5863	5532

[a] Preliminary.

Source: Production, imports and exports—Bureau of the Census. The classification of newsprint by the Bureau of the Census conforms with the Treasury Department definition of newsprint relative to paragraph 1772 of the U. S. Tariff Act of 1930 and subsequent Treasury decisions.

United States mill inventories—Newsprint Service Bureau.

Consumers inventories—estimated by the Forest Products Division, BDSA, Department of Commerce, from American Newspaper Publishers Association data. The net new supply of newsprint received by the 525 newspapers, reporting to ANPA in the year 1957 (consumption adjusted for annual change in inventory) represented 74% of total United States new supply. Total United States consumer inventories for 1958 are estimated on the basis that the inventories of the 525 newspapers reporting to ANPA represent 74% of total consumer inventories. For 1956 the 525 newspapers were estimated to represent 75.5% of total inventories, and for 1957 76.6%. For 1955 and prior years the group of newspapers reporting to ANPA were estimated to consume 76% of total newsprint consumption. This percentage relationship will be adjusted annually. In addition newsprint, the ANPA data include other grades of printing paper which are used by these newspaper publishers in the printing of newspapers. Therefore, the estimated total inventory includes both newsprint and other grades of printing papers which are used in printing newspapers as well as the newsprint held by other users of newsprint, such as commercial printers, printers of shopping news, comic books, etc.

Apparent consumption equals production plus imports minus exports adjusted for changes in inventories.

Prepared by Forest Products Division, BDSA, U. S. Department of Commerce.

Table XVI. Newsprint—United States Exports by Country of Destination, 1952–58

(1000 short tons)

Destination	1958[a]	1957	1956	1955	1954	1953	1952	Destination	1958[a]	1957	1956	1955	1954	1953	1952
Total	127	174	152	207	140	47	104	Hong Kong	[b]	[b]	1	10	5	..	..
Europe	10	22	20	46	24	..	9	India and Pakistan	[b]	[b]	..	[b]	1	..	2
Central America	5	5	5	6	6	2	2	Indonesia	[b]	1	2	3	3	..	1
Mexico	13	33	14	9	8	9	20	Philippine Republic	18	24	21	22	16	16	11
Cuba	2	8	13	16	3	1	3	Other Asia	17	15	5	11	3	1	6
West Indies	[b]	[b]	1	[b]	1	1	..	Africa	..	[b]	..	1	1	1	6
South America	58	61	68	82	67	16	43	Others	3	4	2	[b]	2	[b]	1

Table XVII. Converted Paper and Board Products—U. S. Production, 1949–58

(FRB unadjusted index 1947–49 = 100)

Period	1958[a]	1957	1956	1955	1954	1953	1952	1951	1950	1949
Year	166	163	162	156	136	134	120	125	121	100
January	155	156	156	141	123	123	111	138	107	94
February	160	163	162	149	134	136	116	139	111	96
March	158	167	165	153	137	141	118	144	113	96
April	160	163	168	159	141	139	115	146	115	94
May	159	160	157	154	136	132	110	135	110	90
June	165	166	165	158	135	136	113	127	115	95
July	154	147	146	144	124	124	105	108	111	85
August	177	173	166	159	139	137	121	116	132	105
September	179	173	168	165	141	140	129	115	130	109
October	192	177	177	177	152	143	139	120	141	120
November	176	171	165	161	140	136	135	108	135	112
December	158	142	148	149	131	121	125	102	133	98

[a] Preliminary.

Source: Federal Reserve Board.

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industries expect to increase their spending by 5% over 1958 to $608 million. The annual rate during the January–March period of this year is estimated at $590 million, and is expected to rise sharply in April–June to an annual rate of $680 million.

Converted Paper and Board Products Trends

John R. Mutzabaugh

IMPROVED market conditions in the closing months of 1958, which enabled the converted paper and board products industry to set a new annual production record, are expected to continue through the current year. Provided the gains in output anticipated for most of converting's industrial outlets in 1959 are realized, and production in the opening months indicates an excellent start, the converting industry will undoubtedly establish another annual high in production this year.

JOHN R. MUTZABAUGH, Industry Analyst, Business and Defense Services Administration, U. S. Dept. of Commerce, Washington, D. C.

After a slow start in 1958, the majority of converting's industrial markets picked up greatly in the latter half of the year. As minerals account for less than 0.5% of converting output, all of the industrial outlets of consequence to converters are in the durable and nondurable goods manufacturing groups, both of which showed substantial improvement in output during the closing months of the year.

Durable goods production, off 16% from year earlier output for the first 6 months, was down only 6% for the July–December period. Production of nondurable goods, down 3% on the same basis for the first half-year, recovered nicely and showed a 3% gain for the final 6 months.

Food processing, a segment of the nondurable goods group, was the only industrial outlet of importance to converters to show an increase over year earlier output for the first 6 months of 1958. Production was up 1% for the first half of the year and 3% for the second half.

With the exception of the retail and wholesale trades, all of converting's nonindustrial markets showed 1958

Table XVIII. United States Exports of Pulpwood, Wood Pulp, Paper, Paperboard, and Paper Products, 1950–58

(In short tons except where otherwise indicated)

Item	*1958*[a]	*1957*	*1956*	*1955*	*1954*	*1953*	*1952*	*1951*	*1950*
Pulpwood, (in cords of 128 cu. ft.)	101,535	99,615	108,131	61,651	41,207	10,943	16,819	13,074	27,053
Wood pulp, total	515,245	622,386	525,058	630,972	441,863	161,687	211,924	201,908	95,673
Special alpha and dissolving	222,685	249,548	196,874	193,599	152,887	68,503	65,233	31,157	27,634
Bleached sulphite	43,249	72,235	47,015	71,600	57,990	18,473	23,683	44,165	18,364
Unbleached sulphite	22,817	40,792	42,804	46,606	50,914	30,748	34,548	42,843	32,836
Bleached sulphate	152,597	186,336	189,512	207,022	99,202	13,419	11,604	9,557	4,709
Unbleached sulphate	68,980	68,973	41,409	102,948	75,104	28,830	75,864	71,493	9,555
Soda, screenings, and other wood pulp	4,917	4,502	7,444	9,197	5,766	1,714	992	2,693	2,575
Waste fibrous materials, total[b]	107,300	130,733	190,296	166,591	126,858	114,130	142,371	206,438	119,701
Paper, paperboard, and paper products, total	852,775	868,317	781,304	845,177	686,082	475,345	592,401	635,263	371,516
Paper and paperboard, total	728,472	750,737	668,718	735,831	590,954	382,787	499,210	527,857	297,152
Paper, total	334,567	375,217	329,346	404,495	316,770	180,309	317,740	267,108	166,805
Newsprint	127,118	173,690	152,341	207,313	140,395	46,675	104,998	71,295	43,966
Groundwood printing paper, total	15,850	12,551	11,134	11,021	12,361	6,317	35,419	19,618	7,766
Book paper, total	36,306	34,394	33,679	39,325	28,195	20,247	20,452	32,419	19,207
Uncoated	21,530	19,053	17,458	22,727	15,948	11,657	17,115	17,957	14,300
Coated	14,776	15,341	16,221	16,598	12,247	8,590	13,337	14,462	4,907
Fine paper, total	32,977	39,059	33,539	42,342	40,696	33,899	40,450	47,776	38,535
Writing paper	19,974	26,220	22,072	29,630	29,243	24,014	32,128	35,246	29,801
Cigarette paper	8,696	8,993	7,605	8,713	8,465	7,134	5,501	8,790	6,580
Other fine	4,307	3,846	3,862	3,999	2,988	2,751	2,821	3,740	2,154
Wrapping, bag, and converting paper, total	53,809	57,433	40,785	51,104	50,590	33,129	58,596	56,511	28,354
Kraft	38,975	39,402	30,466	39,225	41,529	26,208	47,891	40,797	17,025
Greaseproof and waterproof paper[c]	3,062	2,877	2,890	2,646	2,486	4,794	2,853	5,489	3,843
Other paper	11,772	15,154	7,429	9,233	6,575	2,127	7,852	10,225	7,486
Shipping sack paper	32,840	26,994	28,032	28,244	22,621	20,641	29,793	20,001	11,488
Special industrial	17,196	15,406	16,193	14,588	11,507	10,740	10,139	9,337	7,325
Tissue paper, n.e.c.	13,549	11,718	9,613	7,425	7,164	5,711	5,273	7,297	7,433
Absorbent paper	4,922	3,972	4,030	3,124	3,241	2,950	2,620	2,854	2,731
Paperboard, total	361,994	337,854	300,340	295,557	241,349	172,340	148,907	225,774	98,562
Container board (liners and corrugating)	267,216	255,145	213,447	213,120	170,197	110,349	92,851	134,613	59,940
Boxboard (bending and nonbending)[d]	44,203	38,080	46,489	39,930	33,590	37,320	23,129	50,040	14,944
Cardboard	7,706	9,490	8,559	8,602	8,629	21,432	24,378	14,639	8,254
Other paperboard[e]	42,869	35,139	31,845	33,905	28,933	3,239	8,549	26,482	15,424
Construction paper and board, total	31,911	37,666	39,032	35,779	32,835	30,138	32,563	34,975	31,785
Construction paper	11,474	11,817	10,375	9,667	9,696	8,704	7,826	10,016	8,322
Construction board	20,437	25,849	28,657	26,112	23,139	21,434	24,737	24,959	23,463
Paper products, total	124,303	117,580	112,586	109,346	95,128	92,558	93,191	107,406	74,364
Sanitary and health products	13,155	14,218	15,447	14,423	13,428	11,930	10,674	12,142	9,355
Filing folders, index cards, and other office forms	4,619	4,553	3,886	3,010	3,895	3,941	3,483	3,699	3,772
Skipping sacks	11,107	9,934	9,722	11,274	9,175	8,946	12,985	19,803	10,128
Paper bags	4,680	4,810	5,593	6,496	4,040	4,833	5,296	6,462	7,101
Shipping containers	10,848	11,514	12,923	12,680	12,992	13,407	15,230	14,867	7,795
Boxes, cartons, and containers	14,062	16,788	12,539	10,834	9,112	10,807	12,504	12,475	8,044
Other paper and paper products	65,832	55,763	52,476	50,629	42,486	38,694	33,019	37,958	28,199

[a] Preliminary.
[b] Excludes rags for paper stock (code deleted July, 1953).
[c] Includes glassine and vegetable parchment.
[d] Includes 10,357 tons of "Special Food Board" in 1958. Separate data are not available for earlier years.
[e] Includes "Wet Machine Board."
Source: See Table I.

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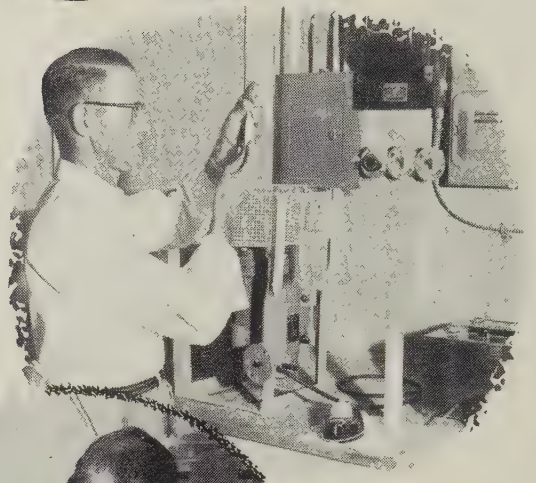

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The 3715 handles a wide range of corrosive liquids. It is available from stock in Type CF-8M (316) stainless, Gould-alloy 20, all-iron, aluminum bronze, bronze-fitted or iron with stainless trim. Ten sizes. Temperatures to 350 F. Capacities to 720 GPM, heads to 280 feet.

Write for Bulletin 725.4: Goulds Pumps, Inc., Dept. TA-69, Seneca Falls, N. Y.

GOULDS PUMPS

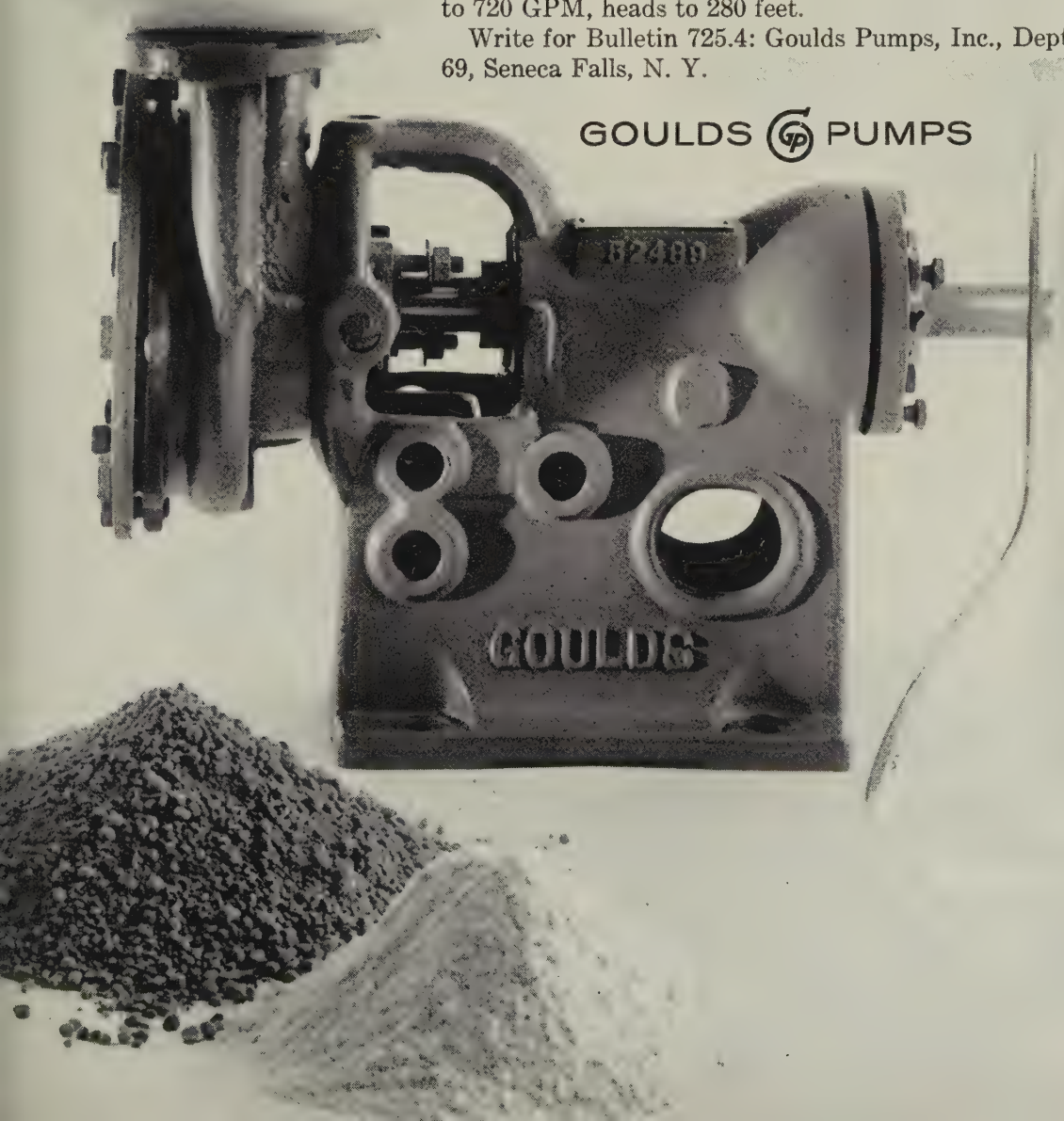

Table XIX. United States Imports of Pulpwood, Wood Pulp, Paper, Paperboard, and Paper Products, 1950–58

In short tons, except where otherwise indicated

Item	1958[a]	1957	1956	1955	1954	1953	1952	1951	1950
Pulpwoods, total (in cords of 128 cu. ft.)	1,465,884	1,767,410	1,869,652	1,764,847	1,602,978	1,552,340	2,124,880	2,511,401	1,412,365
Rough	372,599	461,800	407,309	321,872	428,370	453,745	820,275	883,390	373,460
Peeled	600,013	773,829	910,941	882,207	775,549	776,616	1,036,959	1,406,937	884,781
Rossed	12	119	.....	.....	559	5,603	3,142	3,931	151
Chipped	393,260	531,662	551,402	560,768	398,500	316,376	264,504	217,143	153,973
Wood pulp, total	2,103,410	2,100,657	2,332,337	2,214,119	2,050,760	2,157,574	1,936,687	2,360,734	2,384,975
Special alpha and dissolving	124,827	126,727	174,091	207,734	230,384	255,523	222,608	230,800	238,846
Bleached sulphite	413,637	383,919	407,092	371,438	288,396	333,538	276,698	348,541	401,776
Unbleached sulphite	217,156	281,669	389,891	358,473	339,418	380,397	431,678	557,357	528,673
Bleached sulphate	858,675	749,767	728,621	687,060	637,193	590,224	519,035	521,560	450,352
Unbleached sulphate	251,031	278,465	304,100	282,036	269,852	292,593	207,871	335,573	440,378
Soda pulp	27,320	36,954	42,669	41,333	37,936	34,958	28,073	33,373	33,947
Chemical screenings	10,958	13,550	12,689	8,705	[1]	6,688	4,260	10,344	4,695
Bleached mechanical groundwood	16,809	36,436	48,109	50,879	62,830	65,255	34,341	17,675	20,202
Unbleached mechanical groundwood	181,145	191,816	222,807	203,122	173,731	194,103	207,899	300,418	260,347
Mechanical groundwood screenings	1,852	1,354	2,268	3,339	11,020	4,295	4,224	5,093	5,759
Waste fibrous materials, total	61,759	69,374	66,981	83,975	50,434	65,334	78,825	116,510	131,155
Rags for paper stock	1,995	2,780	3,680	5,761	3,949	5,165	7,528	20,219	25,300
Other pulp-rag, straw, esparto, etc.	460	676	415	200	137	443	217	254	88
Other waste fibrous materials	59,304	65,918	62,886	78,014	46,348	59,726	71,080	96,037	105,767
Paper, paperboard, and paper products, total	5,135,945	5,457,111	5,835,000	5,383,066	5,187,317	5,231,326	5,191,126	5,152,322	5,007,384
Paper and paperboard, total	5,099,818	5,422,661	5,799,310	5,359,504	5,169,018	5,212,819	5,173,352	5,139,254	4,998,347
Paper, total	4,979,777	5,306,249	5,678,584	5,243,316	5,068,365	5,085,015	5,088,038	5,022,617	4,910,919
Newsprint	4,883,274	5,221,256	5,569,481	5,158,827	4,992,089	5,004,050	5,033,014	4,962,562	4,862,995
Printing paper, uncoated	36,709	37,675	55,096	40,722	35,783	41,450	42,984	47,326	35,278
Fine paper, total	4,143	3,597	2,530	2,279	2,387	3,344	1,314	1,333	1,229
Writing paper	1,788	1,281	875	885	602	90	79	74	115
Bristols	205	407	360	289	315	446	156	258	259
Thin paper	2,022	1,793	1,153	936	1,348	2,645	952	799	710
Other fine paper	128	116	142	169	122	163	127	202	145
Wrapping, bag, and converting paper, total	53,544	41,083	48,128	40,110	36,188	35,328	10,331	11,079	10,864
Kraft wrapping	45,717	33,268	40,009	34,335	29,144	29,253	8,656	6,876	7,330
Greaseproof and waterproof paper	2,374	2,233	2,081	2,373	2,880	1,769	564	2,130	1,148
Wrapping, except kraft	5,453	5,582	6,038	3,402	4,164	4,306	1,111	2,073	2,386
Tissue and crepe paper	1,852	2,275	3,045	1,090	1,751	716	266	223	452
Absorbent paper	255	363	304	288	167	127	129	94	101
Paperboard, total	39,267	37,480	32,512	47,563	53,396	98,356	56,979	81,122	54,644
Kraft container board	18,519	17,575	12,193	18,159	22,373	33,325	4,385	967	.....
Other container and boxboard	21	60	250	63	117	375	175	1,739	465
Other paperboard	20,727	19,845	20,069	29,341	30,906	64,656	52,419	78,416	54,179
Construction paper and board, total	80,774	78,932	88,214	68,625	47,257	29,448[b]	28,335[b]	35,515[b]	32,784[b]
Building paper	1,331	1,121	1,878	4,691	1,765	3,762	1,555	2,253	2,055
Building board	79,443	77,811	86,336	63,934	45,492	25,686[b]	26,780[b]	33,262[b]	30,729[b]
Paper products, total	36,127	34,450	35,690	23,562	18,299	18,507	17,774	13,068	9,037
Papeteries	117	258	168	130	84	139	219	133	155
Surface-coated papers	5,276	5,604	4,678	1,879	1,401	1,055	2,404	1,002	265
Uncoated papers, decorated or covered with a design, etc.	80	131	61	27	28	64	78	103	25
Wallpaper	6,180	4,254	6,615	3,658	4,034	3,224	2,879	2,303	2,638
Decalcomania paper	540	553	701	763	633	776	608	1,277	1,110
Boxes of paper, papier-mache, or paperboard (not covered or lined)	1,848	1,834	1,742	1,172	744	810	1,119	543	479
Boxes of paper, papier-mache, or wood (covered or lined)	1,060	938	611	195	243	95	204	96	67
Manufacturers of papier-mache, n.s.p.f.	510	450	432	297	225	198	163	154	106
Manufacturers of pulp, n.s.p.f.	1,105	364	172	95	97	87	78	268	96
Bags and articles of surface-coated, parchment, or similar papers	239	176	153	187	191	283	229	181	168
Albums, photograph, autograph, scrap, etc.	37	36	23	13	4	3	4	2	6
Envelopes	72	51	77	159	139	137	182	126	47
Gummed, paper, n.s.p.f.	16	13	66	101	64	30	9	211	19
Tubes for holding yam and thread	158	167	216	238	134	89	54	69	22

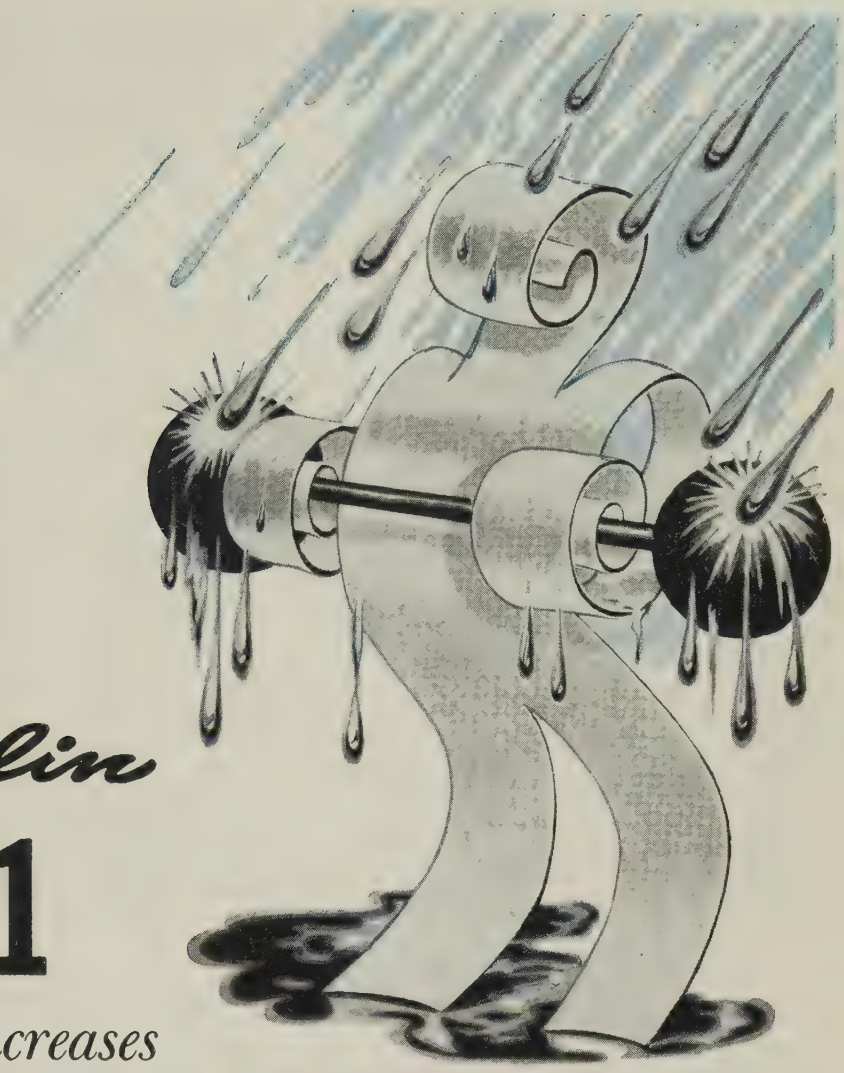

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Table XIX. United States Imports of Pulpwood, Wood Pulp, Paper, Paperboard, and Paper Products, 1950–58 (*Continued*)

In short tons, except where otherwise indicated[b]

Item	*1958*[a]	*1957*	*1956*	*1955*	*1954*	*1953*	*1952*	*1951*	*1950*
Ribbon flycatchers	235	73	583	98	290	204	83	44	115
Masks of paper, pulp or papier-mache	41	20	21	32	24	29	30	32	8
Papers, n.s.p.f.	1,812	1,615	2,621	2,510	2,569	2,866	2,185	1,729	1,133
Manufacturers of paper, n.e.s.	16,801	17,913	16,750	12,008	7,395	8,418	7,246	4,796	2,578

[a] Preliminary.
[b] Included in mechanical groundwood screenings.
[c] Some grades included in other paperboard for years 1950 through 1953.
Source: See Table I.

Table XX. Wholesale Price Index Numbers for Selected Subgroups and Classes of Wood Pulp, Paper, Paperboard and Converted Products, and Other Selected Commodity Groups, 1949–58

(Index 1947–49 = 100)

Item	*1958*[a]	*1957*	*1956*	*1955*	*1954*	*1953*	*1952*	*1951*	*1950*	*1949*
All commodities other than farm and foods	126.0	125.6	122.2	117.0	114.5	114.0	113.0	115.9	105.0	101.3
Pulp, paper, and products group	131.0	129.6	127.2	119.3	116.3	116.1	116.6	119.6	100.9	98.5
Wood pulp subgroup	121.2	118.8	117.7	113.0	109.7	109.0	111.5	114.4	95.6	97.0
Sulphate, Southern, unbleached	121.4	121.4	120.5	114.7	102.4	97.3	109.9	120.7	88.5	89.2
Sulphate, bleached	116.8	114.9	113.3	109.9	107.9	107.9	107.9	116.3	93.9	101.5
Sulphite, bleached	123.9	121.0	102.0	115.0	112.0	112.0	112.0	112.0	98.1	98.7
Mechanical	111.6	111.6	111.6	101.9	105.2	110.0	118.1	122.1	89.6	91.5
Soda, bleached	121.0	118.0	117.0	114.3	112.9	112.9	112.9	112.9	96.5	97.9
Waste paper subgroup	88.3	77.2	112.3	110.7	80.4	90.7	70.1	188.2	119.5	61.3
Books and magazines	69.0	78.9	100.2	93.0	70.6	65.6	110.2	195.9	114.4	71.7
Folded news	94.6	78.6	113.4	112.8	84.9	98.3	67.2	148.8	114.6	65.7
Mixed paper	57.0	42.0	124.3	118.3	82.3	96.9	56.6	193.9	128.3	48.8
Corrugated	110.7	89.7	107.1	111.3	81.1	93.9	61.4	207.3	119.5	61.2
Paper subgroup	142.3	141.9	137.3	129.8	126.6	125.6	124.0	119.1	106.5	103.8
Paper, except newsprint class	143.1	142.9	138.0	129.3	125.1	123.7	123.5	120.4	106.5	103.3
Printing paper	130.6	128.5	122.5	119.0	117.0	117.0	117.0	110.7	102.7	102.2
Bookpaper	148.3	146.3	141.8	132.2	128.4	127.4	125.8	119.8	108.5	105.2
Wood bond	144.5	142.8	136.6	125.7	120.0	118.6	117.8	115.7	105.2	103.1
Writing paper	141.6	139.6	135.4	130.7	123.8	127.1	127.1	125.1	110.5	101.4
Wrapping paper	146.6	149.7	143.9	133.5	132.3	127.5	124.5	122.3	106.7	103.1
Butcher's paper	146.8	146.4	142.2	132.6	130.9	128.6	128.1	126.8	108.5	102.7
Waxing paper	137.0	137.6	134.7	124.2	117.9	118.0	124.4	122.7	103.9	102.4
Wrapping tissue	127.2	135.2	131.2	125.6	120.7	115.7	122.8	132.2	100.0	99.4
Newsprint class	140.6	139.8	136.0	131.7	131.4	131.1	125.7	115.4	106.2	105.5
Paperboard subgroup	136.2	136.3	134.8	127.1	124.5	124.3	127.4	131.8	105.0	98.8
Container board class	125.0	125.0	123.7	119.9	119.9	117.2	115.6	117.8	102.8	100.5
Folding boxboard class	157.7	157.5	155.1	144.1	138.3	140.1	144.8	150.0	109.7	99.4
Set-up boxboard class	131.5	132.6	131.6	119.1	114.4	117.1	128.1	135.9	103.1	94.3
Construction paper and board subgroup	143.2	141.6	136.9	130.9	127.8	121.4	115.3	113.4	107.6	104.2
Converted products subgroup	127.7	126.1	123.1	113.9	112.0	112.2	113.8	116.9	97.7	97.1
Sanitary papers, etc.	123.6	123.4	119.8	118.5	117.9	117.4	118.5	118.7	105.1	103.5
Paper bags, shipping sacks	136.6	132.8	127.2	111.2	110.9	114.2	114.9	116.5	98.0	98.8
Boxes, shipping containers	128.8	126.9	123.8	114.3	111.9	110.6	112.7	117.3	95.8	95.2
Packaging accessories	99.0	99.6	105.4	104.8	101.2	112.1	113.4	114.9	94.3	92.8
Games, toys, novelties	137.9	130.6	135.6	125.0	123.8	123.8	115.7	114.1	106.1	104.3
Office supplies	122.3	121.9	118.8	114.6	112.7	112.4	113.9	112.5	105.9	105.1
Fuel and power group	112.7	117.3	111.1	107.8	108.1	109.5	106.6	106.7	103.0	101.9
Cemicals and allied products group	110.4	109.5	107.2	106.6	107.1	105.7	104.5	110.1	96.3	94.8

[a] Preliminary.
Source: Prepared by the Forest Products Division, Business and Defense Services Administration, Department of Commerce, based upon data supplied by the Bureau of Labor Statistics, U. S. Department of Labor.

increases over year earlier output for the first half of the year. The nonindustrial category includes the retail and wholesale trades, household operation, exports, and governments.

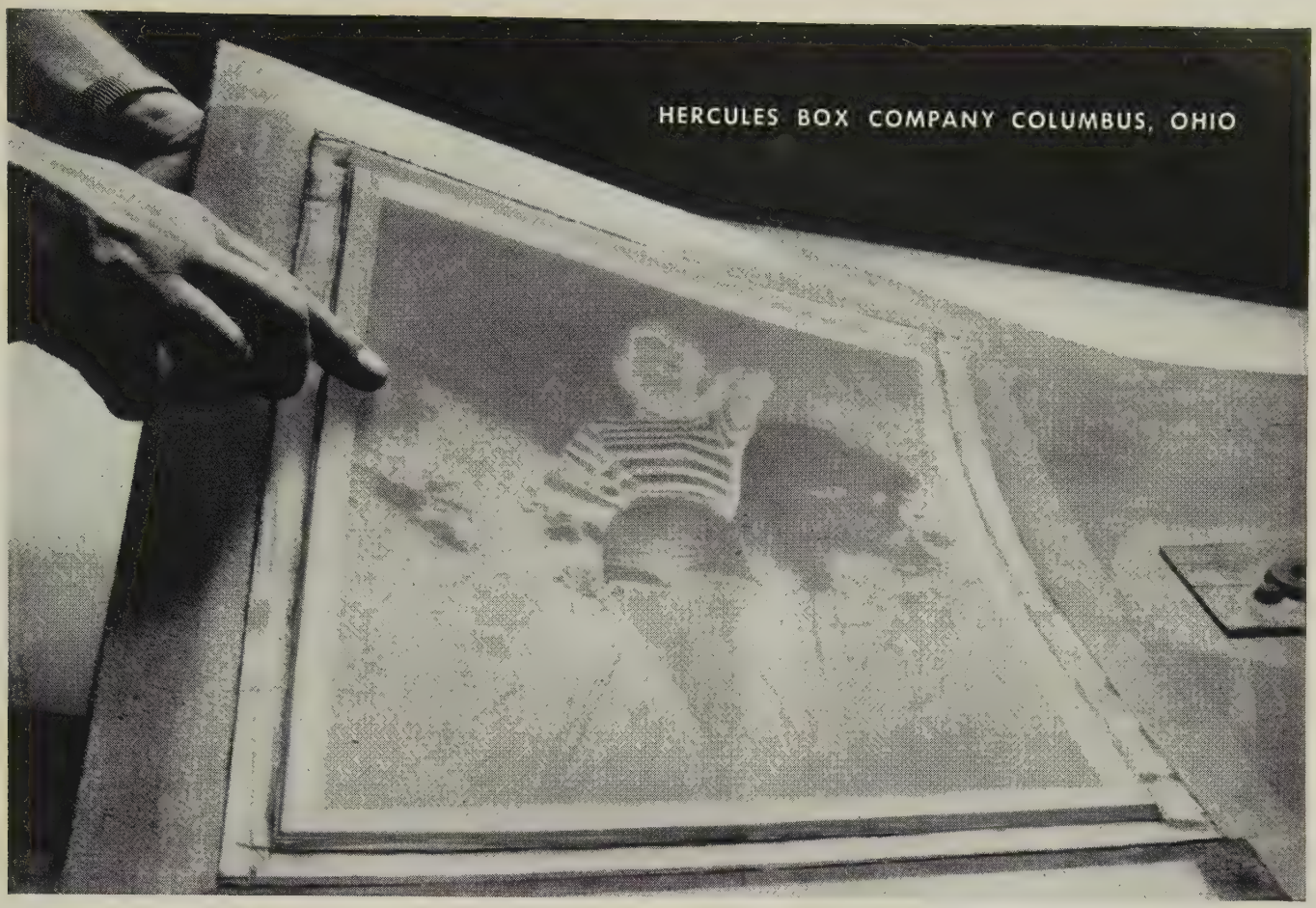
Export trade in converted products was the only unit of this group that did not either retain or improve its first-half showing in the last 6 months of 1958. Foreign shipments were up 11% for the January–June period over the same months of 1957 but increased only 1% for the latter half of the year.

As a result of the over-all improvement in market activity in the closing months of 1958, converting set several new production records. A new monthly high was achieved when converting output rose to 192 for October on the Federal Reserve Board's index of industrial production. The previous peak month high of 177 was established in October of 1955. A new annual record was reached as production averaged 166 for the year by the same measure, a gain of 2% over 1957, when the former annual high of 163 was attained.

A continuation of increased market activity through 1959 is anticipated. Industrial outlets are expected to increase production an average of 5% over last year, according to the Annual Survey Outlook for Major Industries, compiled by the Business and Defense Services Administration (BDSA), U. S. Department of Commerce.

In the nondurable goods field, BDSA expects chemical output to increase 5% over 1958, food and beverages 3 to 5%, printing and publishing 7%, and paper and board 4%.

The textile and apparel industry, which contributed more than any other industry to the average rise in production of the nondurable goods group in the latter half



Uses halftones for printing, Cities Service Wax for coating

Tired of being restricted to line art on corrugated? So was Hercules Box Company—and despite the skeptics, Hercules did something about it.

Today, thanks to a special plastic die developed by Hercules it is possible to print halftone photographs on corrugated!

Creative thinking such as this dominates all that is planned or purchased at Hercules . . . and is clearly reflected in their choice of Cities Service Pacemaker Wax.

Cities Service won the wax role at Hercules because in its own way it is as far ahead of competition as Hercules itself.

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Moreover, the quality of Pacemaker Wax cannot be surpassed. Made in the world's most modern wax refinery and subjected to the most exhaustive testing in the industry, Pacemaker gives maximum resistance to blocking and moisture transmission, has excellent tensile strength, hardness, gloss, and gloss retention.

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Typical Example of the results Hercules achieves with its halftone printing process is this corrugated box for dishware. Hercules also pioneered use of fast drying water based inks.

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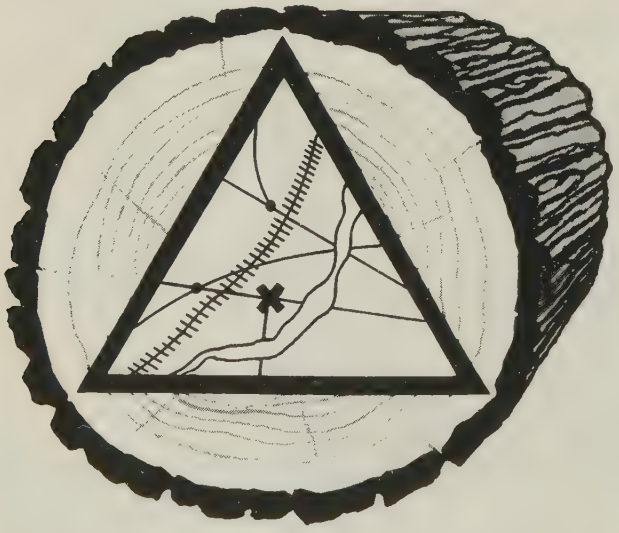
of 1958, is expected to show only a modest increase for 1959 over 1958. The Out-look Survey does not give the specific percentage of gain anticipated but simply states "The industry now is in an upturn, but the degree of prosperity will vary in the several segments. Foreign trade competition is a disturbing factor."

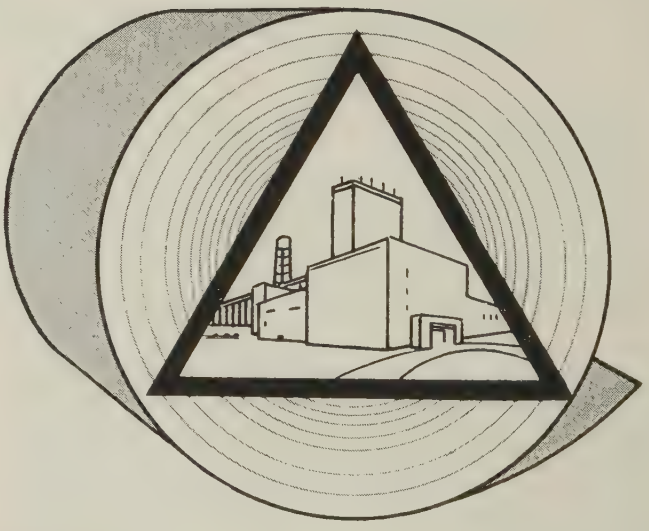
For durable goods manufacturing, BDSA estimates that output will rise 5% above 1958 but with considerable variation among the individual segments. For example, machine tool production is expected to improve only moderately while the output of materials handling equipment may rise as much as 20%.

Provided the industrial outlets, which as a unit account for 58% of converting production, realize their expected 1959 gains, the converting industry will be assured of another record year. Last year when output in the industrial markets, as measured by the Federal Reserve Board Index, dropped an average of 6% from 1957, converting had an increase in production of 2%. Based on this relationship, should both durable and nondurable goods manufacturing approximate their expected 5% gains in output for 1959 over 1958, converting production should increase at least 8%.

Production in January and February indicates that the industrial outlets have made an excellent start toward the 1959 gains estimated by BDSA in its Outlook Survey. Durable goods production was up 8% for January and 13% for February over the same months of 1958. Nondurable goods output rose 8% in January and 10% in February.

FROM SITE SELECTION TO PAPER PRODUCTION





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100-Inch Inconel Alloy Screen Plates have handled pulp at a pH of about 4.5 for over 2 years without sign of wear. Previous screen plates lasted 3 to 4 months. Plates made by Union Screen Plate Company, Fitchburg, Mass.

6 times the life of previous plates...

Inconel screen plates still in good condition after two years of handling pulp at 4.5 pH

In the midwestern plant of a large paper company, "Bird" screen plates handle pulp at a pH of about 4.5. At times, the pulp contains a 20% clay filler.

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In the search for a material that would provide more efficient screening, the company installed several sets of 100-inch Inconel* nickel-chromium alloy plates.

These plates paid off

The Inconel alloy plates have been on the job now for over two years. Six times the life of previous plates and there's still no appreciable wear!

Keep that Inconel alloy story in mind next time you replace screen plates. Remember, too, that Inconel and other Inco Nickel Alloys are solving some of the most difficult corrosion problems in the paper industry.

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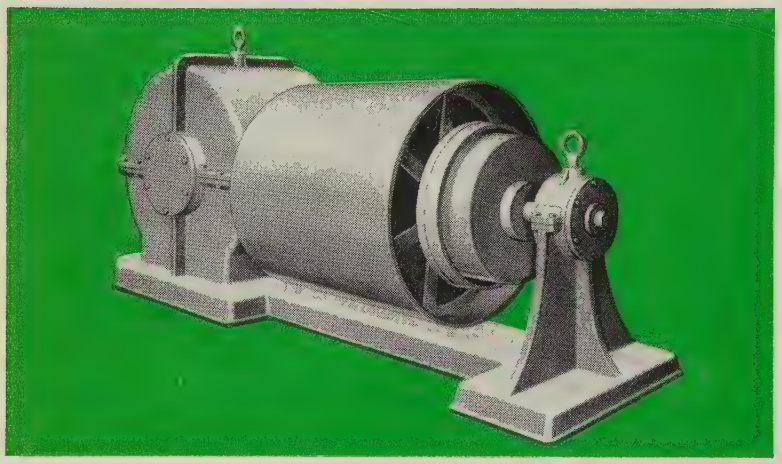


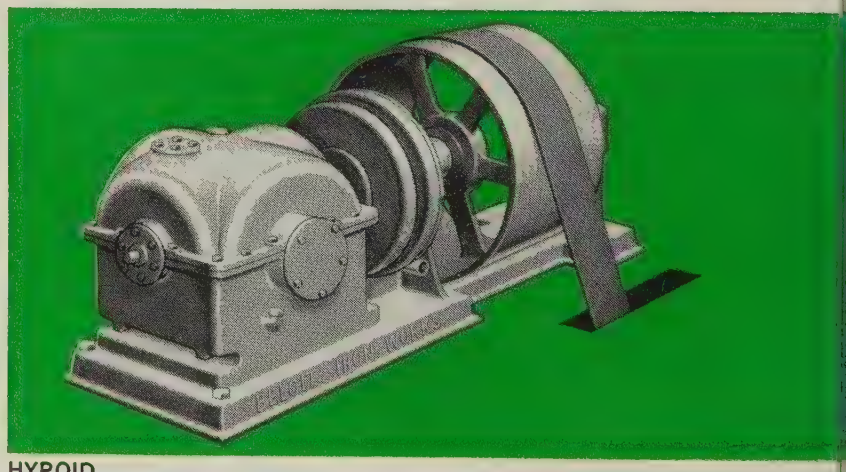
SPIRAL BEVEL

Modest horsepower requirements?

If horsepower requirements are modest, consider the Beloit spiral bevel drive arrangement. This drive is particularly suited to the moderate-speed machine requiring relatively low horsepower. This simple, economical drive embodies top-quality components and is designed for efficient operation over a wide range of weights and draw conditions. A rugged, low-priced unit with a fine performance record.

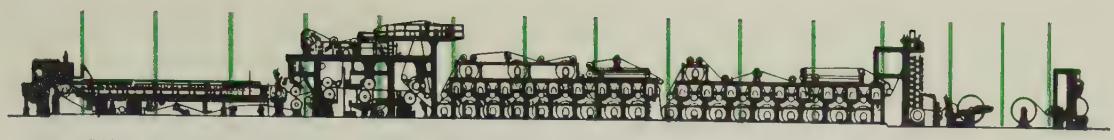
High horsepower requirements?

Beloit's rugged hypoid drive units are designed to carry high horsepower. This drive has given outstanding performance on wide machines running in the upper speed ranges. New design features have added to the inherent advantages found in this particular drive arrangement. Hypoid units can be driven from basement or overhead line-shaft setups.



HYPOID

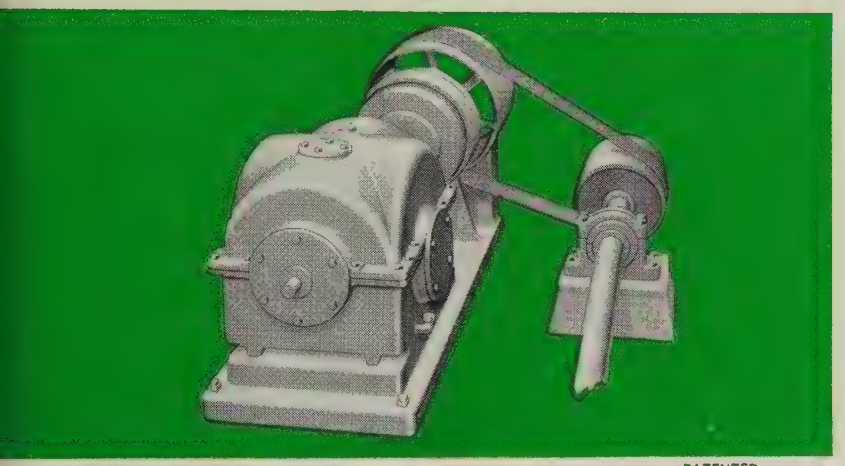
PROVED BELOIT UNITS: HELPER TYPE DRIVES · RUGGED BELOIT AIR CLUTCHES · SLACK TAKE-UP ARRANGEMENTS · INCHING DRIVES



ONE OF A SERIES SHOWING TYPICAL BELOIT SOLUTIONS TO COMMON MILL PROBLEMS

Improve PRODUCTIVITY

A paper machine is no better than its drive. So a paper machine modernization program will almost always include some drive changes. Greater machine efficiency and productivity often can be obtained with only minor drive changes. Other situations may call for a completely new drive. Whatever the circumstances, Beloit drive units offer the rugged dependability that mills require in a paper machine drive. Beloit drive systems supply the required horsepower for given speed levels . . . provide accurate speed settings . . . maintain stability under varying load conditions . . . and hold precise draws. Drives shown below merit your careful consideration.



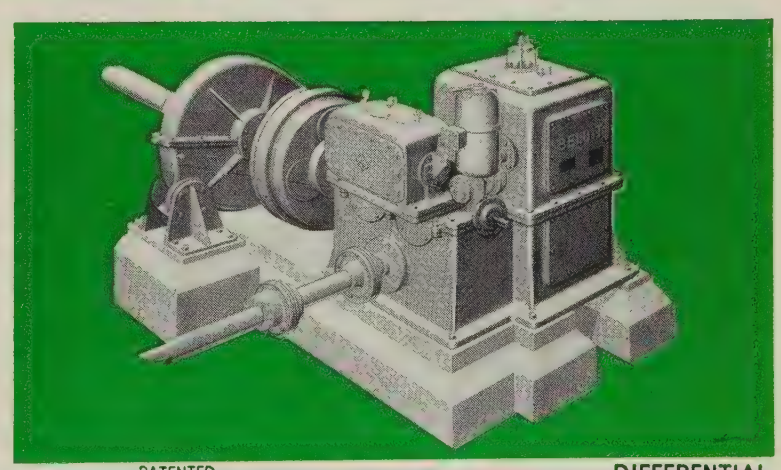
SHORT-CENTER PATENTED

Need a floor-level drive?

If a floor-level type drive is in order, consider Beloit's short-center units. This drive arrangement keeps machine-room basement clear for auxiliary machine equipment or storage. Short-center arrangements are particularly adapted to machines with modest horsepower requirements where basement space limitations exist.

High-speed draw problems?

Beloit differential drives provide an accuracy of draw many times better than previously available. A common lineshaft located at machine-room floor level ties all sections of the machine together mechanically. This drive is unequalled for application to wide high-speed machines or special-duty machines where the problem of maintaining draw between sections of differing mass is important. Many mills have chosen to apply differential-drive units to sections where the draw becomes a critical factor, thus gaining the advantages of Beloit's differential arrangement without the necessity of adding a complete machine drive.



PATENTED DIFFERENTIAL

ACT! *Take advantage of Beloit's experience in the design and building of mechanical drives, each built in the Beloit tradition of fine craftsmanship. Write to Beloit Iron Works, Beloit, Wis.*

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PAPER MACHINERY

your partner in papermaking

Merchants?—The Old and the New!

CHARLES E. CAULFIELD

THIS business of having me here to speak to the Salesmen's Association and their guests is getting to be a bad habit. George Goebel said you can't make a silk purse out of a sow's ear, but if you insist on trying you ought to get a silk pig. You fellows should know by this time you can't make a speaker out of me and quit trying. I don't know just how many times I have been up here, but I do know that the first time was 10 years ago in 1949 and there were a lot less of you then than now.

Since then much water has run over the dam and through the mills and many things have happened to the paper industry. Right now, there seems to be a great deal of unrest in the paper industry, lots of question marks, much shifting around; shifting of jobs, shifting of outlets, shifting of suppliers, shifting of customers. Also, everybody is joining everybody else. Nobody seems to know who will own somebody tomorrow morning. These changes seem to cause quite a bit of consternation and much "viewing with alarm." Everything is going to hell in a wheel-barrow—and particularly the merchants. The merchants are dumb—the merchants are stupid—and the merchants are dying on the vine.

As a matter of fact, according to some experts the merchants are already dead. If that is so, then there are an awful lot of merchants walking around just to save funeral expenses. That could be true, right now, so soon after that April 15th deadline, but somehow some of them always seem to come back to life with a bang just about the time you think you have that juicy order all sewed up.

Anyhow, dead or alive, merchants do manage to buy and to sell—at some kind of profit—a powerful lot of paper (about $7^3/_4$ million tons, over 3 billion dollars worth, last year). That's about 66% of all the tonnage made in the kind of grades merchants sell, and it is not to be sneezed at by any mill sales manager. So, the crucial question is: if all these dying merchants can sell that much paper, how much could live ones sell, and who's going to sell it if they all die?

It's a neat little question—and a lot of experts have been making surveys and reports. One of these experts sent out a letter recently in which he presented the high lights of his personal survey of paper merchants. Typical of so many of these surveys, what he says is absolutely true, but the implied conclusions are not. I will read this letter to you, with some facetious asides for which I apologize ahead of time. . .I tried to leave them out, but the temptation was just too great.

He says:

1. "If the present trends are not arrested, the paper merchant will commit mass suicide—will go the way of the food wholesaler. At the moment, paper merchants as a group are a sick segment of our economy. A majority earn less than 2% on sales."

(It's true and it's been going on for generations.)

2. "Many companies are overorganized: too many chiefs for the Indians involved; too much nepotism."
(Nepotism means favoritism shown to relatives. I am one of them. There are some in the mills also.)
3. "Some paper merchant executives are content to draw good salaries, without looking to the survival of their companies. Many are one-man institutions which fall apart at the death of the principal."

(I wish more of them would.)

4. "Warehousing methods are frequently antiquated and inefficient—hence costly."

(Like mine, they can be antiquated and inefficient, but not necessarily too costly).

5. "Very few merchants know what basic records are needed; hence there exist overlapping or useless information-gathering routines."

(Some don't have any.)

6. "Adequate market research is almost unknown to paper merchants."

(It's less confusion that way.)

7. "Many sales managers are super-salesmen—rather than even average sales administrators. The efforts of salesmen are largely unplanned, unsupervised and uncontrolled. Some seem to work for the benefit of their salesmen, rather than the reverse. In fact, many merchants are afraid of their salesmen."

(Alas! too true.)

8. "The value of a paper merchant as 'middle man' should lie in credit extension, service, storage, quick delivery, and small lot sales. By passing these economic functions back to the mills, paper merchants are slowly putting themselves out of business."

(You can make money by not farming a Vermont farm, too!)

9. "In the long run it is the hidden costs which will cause many merchants to disappear. Their prosperity is more apparent than real.

(What do you mean–hidden!)

"If you would like to review with me our ten point plan for paper merchant survival, write to me in confidence."

(No action taken.)

Mills read this kind of report and begin to wonder. How come this present trend, and how about this mass suicide business? Is it true that merchants as a class are a sick segment of the industry?

Well—maybe so and maybe not! Let's take the New York Paper Trade Association. In 1924, there were 73 members. Today, there are only 23 houses left of that 73. The rest have gone out of business for one reason or another, but not one from having gone broke—I mean bankrupt (all merchants are always broke). Statistically, that is 69% of them dead in 35 years, and if you stop right there, it certainly could sound like mass suicide. But don't think that all you have to do is to sit back and wait for the rest of them to die and then enjoy a life with no competition. Today, there are 85 *new* names on the N.Y.P.T.A. roster—a total of 108 merchants instead of 73, and some of them are pretty rugged competition. That's rather discouraging to a fellow who is just waiting for the competition to die off.

The same is true with mills. I don't believe anyone has added up the number of mills who have closed up or combined, or sold out, in the last 35 years. But those that are left produce four times as much tonnage—and these dying merchants sell a higher percentage of that

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Use STAYCO Starches for wet-end addition, surface sizing, calender sizing, or coating—wherever you need an oxidized starch of optimum dispersibility ... stable viscosity and clarity ... high binding strength ... and *superior brightness*. For additional information, write for Technical Data Sheet No. 104.

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tonnage to new customers, because of bunch of the customers fell by the wayside, too.

As far as not making more than 2% on sales, well few merchants have, since Uncle Sam became a 52% partner, and the average was only $1^1/_2$% last year, but that was still $8^1/_4$% on net worth. It's not enough, but you can live on it.

Those other eight faults I have listed are basic and fundamental and are found to some degree in all companies in any industry. If a company has too many of them, it is not long for this world. But why pick on paper merchants!

Merchants are wondering also, but in a different vein. They feel that somehow or other they are getting a good kicking around and how did they ever get into this kind of a situation anyhow for gosh sakes. They know they are doing a good job of distribution, but all they get is criticism, headaches, and insufficient profits.

I have a theory; as a matter of fact, I have a couple of theories.

The first theory is that what all this really boils down to is a question of proper mill and merchant relationship and that relationship has been changing so much over the years no one knows what it should be—or even what we want it to be.

The trouble is that organizations which buy paper from mills and resell it have been *evoluting*. They might have started as brokers, graduated to jobbers, grown up to be merchants, and are now sometimes merchants and sometimes distributors.

The dictionary defines a merchant as originally a traffiker or a trader; and a distributor as one who distributes or is an agent or agency for marketing goods. Those are better definitions than we in the trade ever thought of.

Historically, a paper merchant bought where he could get the best product at the lowest price and sold it at whatever the market would bear. Sometimes, quite often as a matter of fact, mills had to work plenty hard and often make price concessions to get and hold that business. The merchant knew his markets better than the mills, he knew the mills better than his customers, so he controlled some sizable tonnage and contracts for 500 tons, a thousand tons or 5000 tons were, in the larger markets, ordinary merchant business.

N.R.A., wars, allotments, price controls, and standard mill brands changed all that.

Gradually with the standardization of mill lines and the dissemination of knowledge as to how to make papers and where to sell them, the independent merchant instead of buying his own grades where and when he pleased, began to team up with his mills to distribute their papers in his own individual markets and to act as a partner with his suppliers in a mutual attempt to promote and sell their products, rather than his own. Fundamentally, this was sound good progressive evolution. It worked fine as long as paper was in fairly short supply as it has been mostly for about 15 years.

But we never got around to making any ground rules, and right now, the whole distributor idea is beginning to fall apart at the seams. It shouldn't because economically that's the way a lot of paper should reach the market places.

Most mills know—and admit—that their distributors can sell and deliver a sizable part of their production more economically than they can and at a higher return to them. They also know that their distributors can and do relieve them of a lot of expense and headaches.

Merchants or distributors, whichever you call them, bridge a financial gap, taking credit risks and carrying accounts for 30, 60, or 90 days or more. They pay their salesman to sell the mill's products; they gamble on the quality and the market not changing. They absorb and handle a lot of the detailed problems which mills would never want to be equipped to handle.

They give their suppliers and their customers a terrific amount of service—too much service—but that's another story.

All this is good but expensive and getting more expensive every day. It's an added cost that mills don't have. So an independent distributor feels he should and must have a mill cost as low or lower than anybody else and when he finds that he hasn't, that mills are undercutting their own lines, that publishers, large consumers, large printers selling a package deal, converters and some merchants who wave a little loose tonnage around in the air can and do buy better than he, he is sorely tempted to go back to being a merchant—to being a trader again instead of an agent.

It isn't only a temptation either. Much of his warehouse business is a service business that costs him more than he sells it for. He provides this service for his suppliers and his customers in the hope and expectation of getting other larger profitable orders. As he sees those orders being skimmed off by direct selling mills, (and all mills are direct selling sometimes) and by the above competition, he can see some pretty sad looking handwriting on the wall. He can plainly see that his chosen suppliers by up-grading standard lines and sniping at the market with new lines, are not keeping him competitive where he ought to be competitive. He can also see a lot of the business he counted on, being drained off a little here and a little there until the "old gray mare ain't what she used to be."

To the pessimist it begins to look as if he, the independent distributor, has just about six choices left—none of them to his liking and they shouldn't be to his mill's either. He could:

1. Go back to being an opportunist merchant if it's not too late and he still remembers how.
2. Sell out to a mill and let the mill worry about profits.
3. Sell out to, or combine with, a chain operation which can add strength to his bargaining power and who would use that power.
4. Use his organization, his sales force, and his capital to sell products other than paper.
5. Get the hell out of the business and go back to the farm.
6. Keep on the way he's heading and end up a two-bit retail store.

He really has to face the question "To be or not to be" and he's doing a lot of thinking about that question.

On the other hand the optimist has another viewpoint. He says if we merchants and you mills could get smart enough, we together could work up a seventh possibility which we both could live with and prosper. We'd have to agree that, after about 5000 years of merchant existence, merchants of some kind are here to but maybe they are going to be distributors. Being a distributor isn't so bad, if we have the right mills and we understand each other. There's a lot of paper to be made and distribute right now, and the demand is bound to increase. We can't, any of us, handle all the

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Designed and Built for Paper Mills

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- **Light Gauge Foil and Films**
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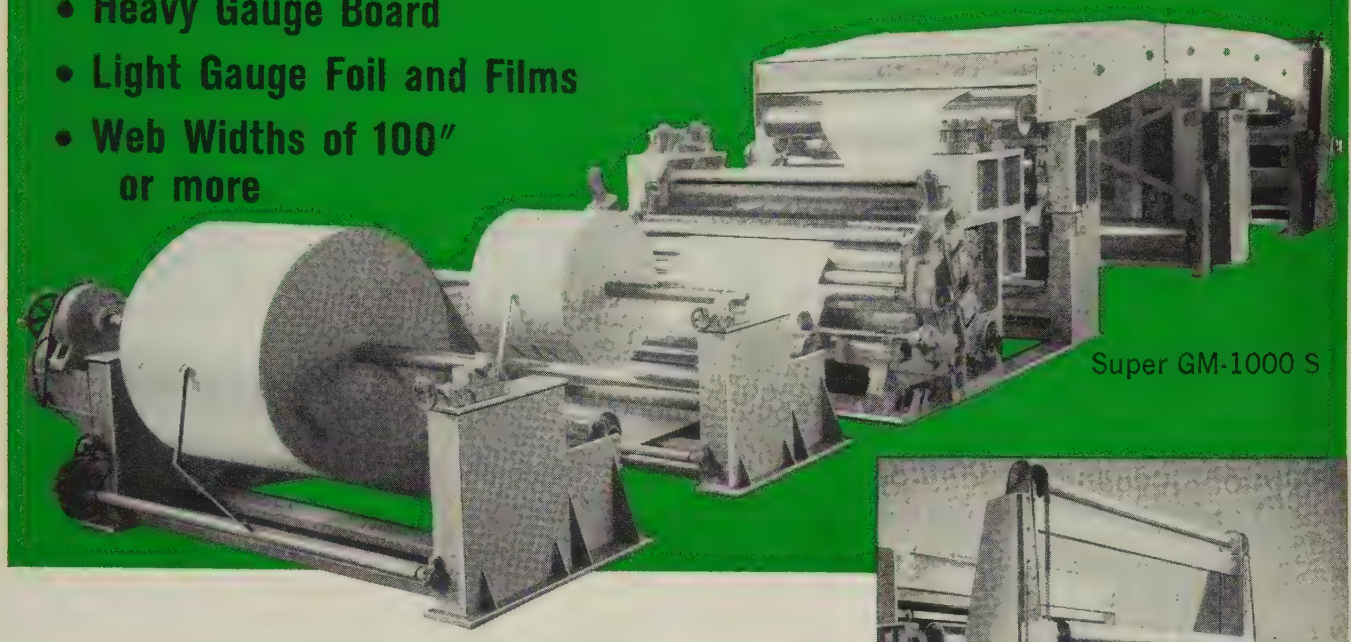
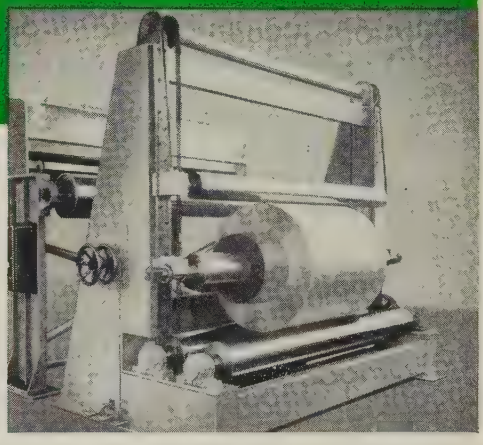


Super GM-1000 S

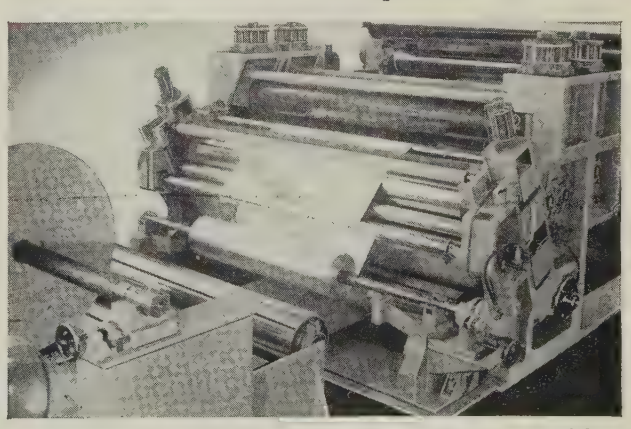
More and more paper mills are extending their operations to include laminating and/or coating of the basic materials they produce.

The Inta-Roto laminator pictured above has been installed at the St. Joe Paper Company, Port St. Joe, Florida. This machine will enable St. Joe to produce high quality laminated and coated stock. The upgrading of their basic paper will mean new sales opportunities.

Inta-Roto laminators incorporate precision devices for tensioning, metering, and nip pressures to assure all-important quality control. These high speed precision machines are built on a unit basis so that you may add units to meet production changes or expansions.



● Water cooling rolls at exit of the Super GM-1000 S drying tunnel, and surface type rewind which handles rolls up to 72″ in diameter.



● The Super GM-1000 S compact, precision station for application of adhesive and hot melts with two combining roll units.

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business. Let's get our share and be smart enough to make a good living doing it. You mills would have to realize that distributors have to be competitive, too, just as well as merchants. There's no room for a "fall guy" in this partnership.

My second theory is that in the paper business—just as in any other business—the pendulum swings back and forth. Some of you, who are younger than I, have seen it only when it was forth and get discouraged too easily when it is back as it is right now. But I have been hanging around the paper business for just about 58 years, and I have seen paper history repeat many times, and now I know that over the years our industry keeps improving and will continue to improve.

SOME PERSONAL HISTORY

So, I'd like to give you a little history, some of it necessarily personal, because that's what makes it real.

Several months ago, the fire department discovered that we had a vault under Duane Street. Said vault was useless except as a last resting place for anything we didn't want anymore and didn't know what else to do with. The fire department declared it a fire hazard and ordered the place cleaned out. There was really quite an assortment which included a pile of old horse collars and harness. Some of us remembered when they were in use. We remembered old Joe Geraghty who owned them and who also owned a couple of drays. Joe handled all of our deliveries and Joe drank beer—gallons of it. Once a year, my Dad would get him by the arm and drag him over to call on the parish priest. Then the two of them would back Joe into a corner and make him sign the pledge! That was good for about six months and our deliveries would be considerably more prompt for awhile. Then they would gradually slip as Joe slipped. I can remember the day we had a rush delivery to the National Cloak and Suit Co. on 25th St. Some time later, our irate customer wanted to know what had happened to that delivery. We went out to ask Joe but he had the perfect alibi. . . the horse dropped dead when he got to 23rd St.

Our shipping clerk was Old Man Bidgood. He was always going to give me a pair of goats and a wagon, but he never did! Probably because my mother firmly declared that *that* day would be his last at Canfield. He was a fine man, but he finally went nuts and tried to bust one of his men with a hammer. I guess all shipping clerks eventually go nuts. It's from trying to keep all of the salesmen happy at one time. Sales managers go nuts too—for the same reason. It's a good thing they don't have hammers. But, I didn't mean to soliloquize!

In those days, first Larry and then Phil were our office boys, and delivered samples for us. We paid them five dollars a six-day week (which was more than they were worth, but the old man was generous).

When we hired Phil, Larry was graduated to the shipping department. Phil rode his bicycle in to work to save subway fare and Larry would ride it around the alley (to save working, I suppose). Eventually, Larry got to be shipping clerk at $12.00 a week. Later he served in the Army overseas . . . when he came back and collected his first week's pay, it was still twelve dollars! (I told you the old man was generous.)

We had no sample department. Salesmen got out their own samples, or maybe even used some one else's if some one else's looked better. There were few mill lines, most lines were private brands and no one was ever quite sure what mill made the last shipment. Each salesman had his own assorted list of prices and the order department had a black note book which attempted to list the right price for each salesman and each customer. The man on the order desk had to be quick on the uptake—that's for sure!

An apprenticeship as office boy, then a few years on the order desk and in the shipping department was our sales training program. After four or five years, if things were pretty slow inside, we sent the boy out to sell—probably at the same twelve dollars weekly salary. We'd give him a list of 100 two-bit printers no one else could sell or would bother to sell and all of them were invariably located on fifth floor walk-ups. About a year later our new "salesman" went on straight commission—no drawing or expense account.

The office help got 14 to 20 dollars per week and no one ever had heard about fringe benefits, pensions, profit sharing, insurance, Blue Cross, city, state, or Federal taxes, or overtime. So there were years when the boss made a pile of dough. There were other years when he lost it, but whatever he made he kept, either for himself or for his business and most of it went to his business. "Them were the good old days" or were they! I forgot to mention that watermarked sulphite bond sold for $7^1/_2$¢ in ream lots and coated for 6¢ and the total production of the paper industry was about five million (5,000,000) tons a year.

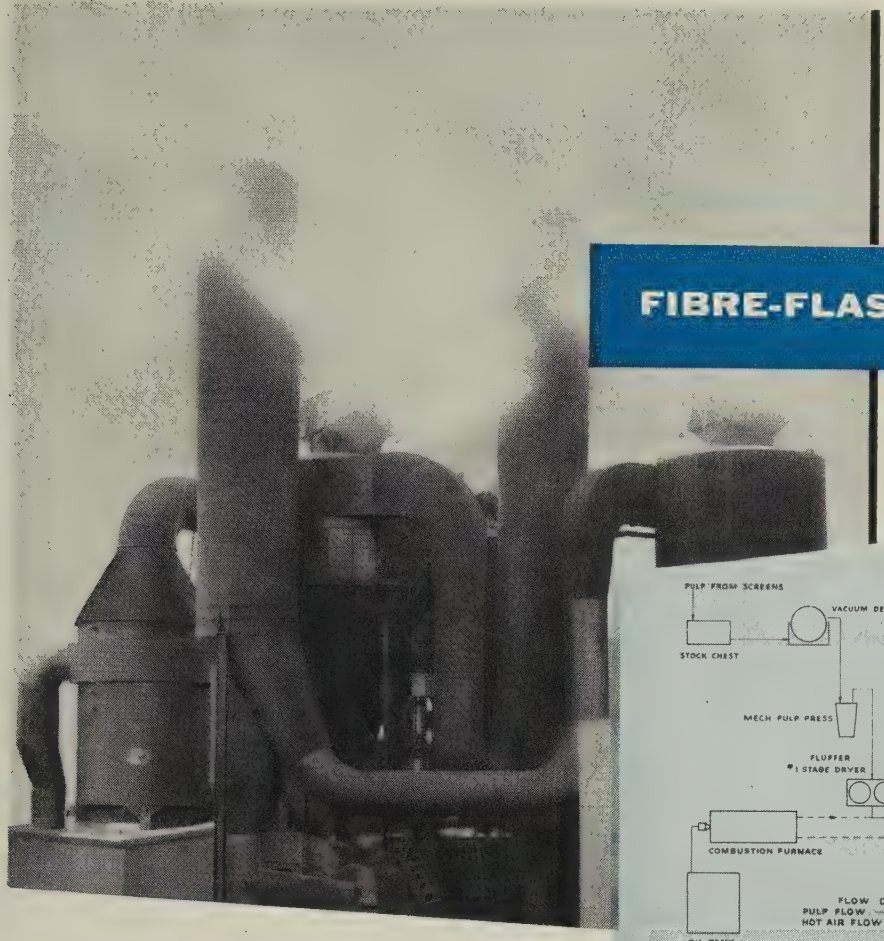
The money was made on grades the customer couldn't identify. There must have been a lot of those, or else some pretty cooperative customers because many a paper house built up substantial reserves which they sure need right now.

In those days a salesman could get sore at the boss and if he had saved a few dollars could walk out and start a new merchant business across the street. Salesmen not only could, but they did, and that's the way most of our present-day merchant houses got started.

In those days nobody talked or bothered about mill and merchant and customer relationships. You bought what you pleased—where you pleased—at the best price you could—and sold it to whoever would buy it at the highest price you could talk them into paying. There was a lot of high-powered horse trading. Everybody understood the rules and horse trading was good. That was the way everybody did business.

No one worried about direct selling mills, direct or indirect buyers, converters, or who bought direct and who bought from merchants. It didn't make any difference in a catch-as-catch-can economy.

This era reached its climax in the boom of 1916. There was supposed to be a wartime shortage of paper. There wasn't! Everyone sold paper, bought it back, and sold it over again several times at fantastic profits. So a lot of paper never stayed put long enough to get printed. Every mill received and accepted orders for a year's output. "Business never was so good." Mills and merchants decided to become statesmen instead of politicians, and never again would there be cut prices. My company's sales jumped from $650,000 to over $2,000,000 and we netted $152,000, before taxes.



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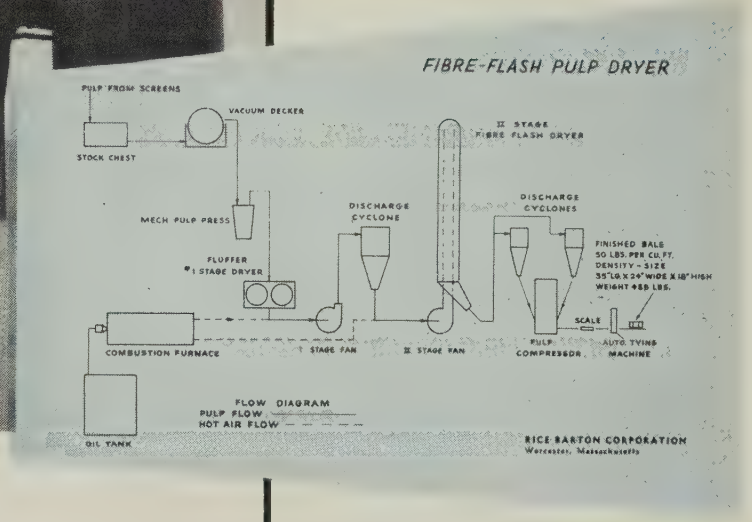

The "Fibre-Flash" drying process for use with all types of pulp consists of dewatering the pulp, fiberizing the concentrated pulp material thoroughly to insure uniform drying, evaporation of the fiber-bound water to the required degree of dryness and baling or bulking the material into convenient form for storage or shipment.

The drying medium, either combustion gases or hot air, carries the material to be dried through separate stages of the fiber-suspension-type flash dryer. The relatively high intake temperature flashes-off the surface water and the drying tower provides the necessary time element to permit a complete heat exchange to extract the remaining moisture in the fibers. Drying occurs at high evaporation velocity which maintains a low fiber temperature.

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Paper Machinery Builders Since 1837

Our net after taxes was $152,000 also, because there weren't any taxes!

The bubble burst suddenly in 1918. I remember we begged one mill to accept an order for 100 tons but the mill was sold out for the year. Two days later we received a wire from the same mill, "Please send us an order so we can run our machines tomorrow." Everybody cancelled everything.

Things were a little tough for a couple of years and all those statesmen went back to being politicians. I believe there was even some talk of cut prices and quite a bit of talk about how salesmen had forgotten how to sell—but a new boom came along in 1920 and our statesmen came back out of the woodwork and the order takers became salesmen again. Prices sky-rocketed, the paper business had at last grown up. It didn't last. Somebody pulled the plug—prices nose-dived and *our* inventory dropped from $260,000 to $100,000 in one day.

1921 was another tough year. Politicians came back and statesmen were hard to find. Paper production dropped a couple of million tons in spite of the fact that prices had gone back down to normal. To catch a greater share of the market, mills upgraded their qualities but soon all mills had upgraded and no one got more than a temporary advantage. Mills tried to hold the line on price but those that were hurting most made inside prices where they thought it would do the most good, and a little later all prices dropped. Each mill was "viewing with alarm" its merchant's inability to increase sales for them and started taking on more merchants and coming out with new and bigger lines. Nothing did much good until a new boom came along, the boom of the golden 20's which saved us all before things got too rough.

Lines became stabilized, prices rose and by 1928 everything was rosy. Mills and merchants decided that now at last we have grown up, now we have an orderly economy, now we can produce and distribute paper in a statesmanlike manner. We are an important industry with a total production of 11 million tons, never again would we resort to cutting prices, rather let us be smart and reduce machine time if things are temporarily quiet, and thus control production.

Then came the deluge. It started in the fall of '29, but the paper business didn't feel the full impact at first. In 1930 some mills began to upgrade their products, then all mills upgraded, so all that was accomplished was to make all inventories obsolete again. Then came the inside price concessions, and then complete chaos. And, brother, I mean chaos. In 1932, we could buy 1800 pounds of a special color in a special size and a special grade at a special price. But it didn't increase the use or the production of paper by one single ton so the total production dropped from 11 million tons in 1929 to 8 million in 1932, and everyone lost their shirts on the 8 million. The Canfield Paper Co.'s total dollar sales for the year were less than one good month now.

It took government intervention and NRA to drag us out of that one, with the able assistance of some real statesmen they found hiding in the good old woodwork, but we did live through it and slowly increased sales about a million tons every year until the second war really pushed us over the hump.

From 1940 to 1956 we enjoyed the longest period of stability and steadily increasing markets that we had ever had. Production rose from $14^1/_2$ million tons in 1940 to over 17 million in '45; to $24^1/_3$ million in '50; to $31^1/_2$ million in '56.

Now we have learned all the lessons from the past. It can never happen again. We will control production, we will hold the line. We must, because we have inflation and unions and taxes and fringe benefits and expensive equipment and bank loans and everything.

Sure! but we also have new machinery built to satisfy the estimated demand of 1965 and with it we again have the jitters.

TODAY

So today again in spite of steady demand at very high levels, only 2% behind the record year of 1956, our inventories are obsolete because of upgrading, and there are lots of inside prices if you know where to look. Everybody is unhappy about the actions or lack of action of everybody else and everybody but thee and me is just a little bit dumb.

Merchant-minded mills are viewing with alarm the inefficiencies, infidelities, and insecurities of their merchants. Merchants are dissatisfied with their mills and alarmed at the actions of other mills. Salesmen are getting kicked around and are prone to question the wisdom of the powers that be, the greener pastures are showing up on the other side of every fence.

So here we are—manufacturing, selling, and using the greatest tonnage of paper the world has ever heard of, and selling it at prices which are fantastically high to an old-timer like me. Yet mills and merchants are afraid—afraid of their own shadows and of the shadow of a comparatively small amount of spare capacity which we should always have anyway and which we are sure we are going to need soon.

Our actions remind me of the farmer's little boy who, on bended knee, hands clasped in supplication, with tears streaming down his face, cried, "Don't sell the farm father, give the damned thing away."

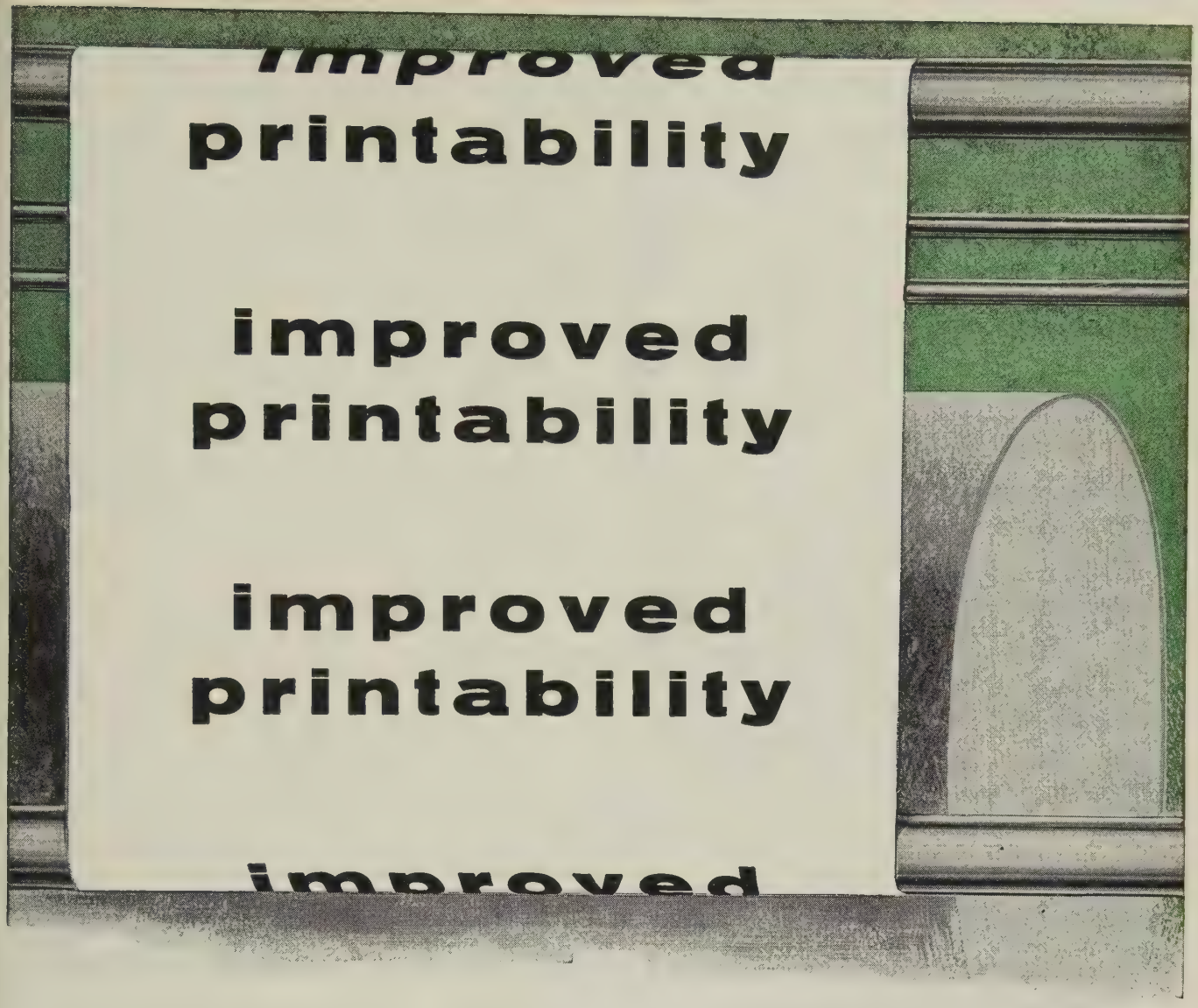
My advice to you mill men and you merchants is—take some tranquilizing pills and relax. The music goes round and round and comes out here. It was so and ever shall be, world without end.

Someone at a mill committee meeting last fall said, "You birds have been chewing your cuds for a couple of years. Right now would be a heck of a time to swallow them." Amen!

That ought to be the end, but it isn't—quite. Every speaker is trying to sell something and is always afraid he hasn't. I guess I am, too, so I want to spell it out.

1. The merchant business, excluding large chains, is essentially a "side street" operation. It can't be run from Park Avenue or Florida. It is apt to be a family affair. A man runs his business, makes a pretty fair living, supports some other families, and eventually retires or dies and goes to Heaven. That may be the end of that particular merchant operation, but there are always new ones to replace it, because merchant distribution is important and serves a useful function and it always will.

2. The paper industry lives and grows and thrives, but in cycles which have their ups and downs. After every down there is a new up, always way ahead of



with Gelva C-3 and C-5 copolymer resins

When used as a surface size, GELVA C-3 and C-5 polyvinyl acetate copolymer resins impart a smooth finish to paper. Ink receptivity is improved. Contrast is sharply defined. Furthermore, when deposited from ammoniacal solution, the resin imparts to the sized sheet a more water resistant film. Improvements in wet and dry tensile and Mullen are also obtainable. The resins are alkali soluble. Broke recovery is quick and easy.

Write for full technical information on GELVA C-3 and C-5. Shawinigan Resins Corporation, Department 6206, Springfield 1, Massachusetts.

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PROPERTIES

Form—Fine beads (0.2—1.0 mm. diameter)
Transparency—Excellent
Light Stability—Good
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	Softening Point	Maximum Flowable Solution
C-5V-10	123°C	20%
C-3V-10	123°C	35%
C-5V-16	134°C	20%
C-3V-20	155°C	25%
C-3V-30	180°C	20%

Softening Point: Ball and Ring Method
Solution: Ammoniacal

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For High Speed Paper Machines with Revolving Syphon Pipes

In the Type LN Johnson Joints the revolving syphon pipe is made a part of the rotating assembly, yet is permitted longitudinal movement. Sealing is still accomplished without packing. Simple support rods carry all the weight of joint and connections, permit the rotating assembly to "float" freely inside. Special hangers and brackets adapt the mounting for machines with either open or enclosed gearing.

Johnson Joints fit all needs on paper machines, calenders, corrugators, waxers, embossers, roofing machines, printing presses. For full data on Type LN write for Bulletin N-2002.

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Joints
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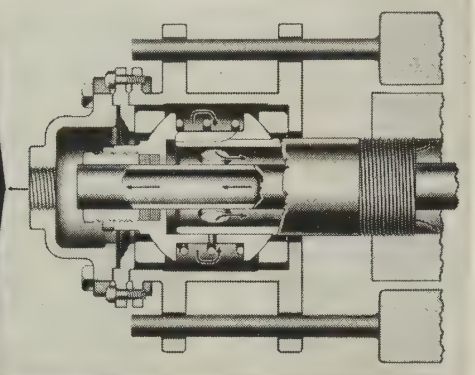

THE JOHNSON CORPORATION
843 Wood St., Three Rivers, Michigan

where we were before. Because of high taxes and high wages, we no longer can afford to have so many downs. Let's be intelligent—avoid panicky actions and consistently use a little statesmanship.

3. You can't have all the business and you couldn't handle it if you had it. For the love of Mike, get smart and make a profit on your share.

4. You can't turn demand on and off like a spigot—so be a little patient. The other guy has new production to sell, too. Maybe you mill men ought to tell your boss this one. He can't turn it on, either, even if he does have machinery notes to meet.

5. People are always going to use a lot of paper and will be willing to pay a reasonable price for it.

Maybe this isn't such a bad business to be in, after all.

Presented at a meeting of the Salesmen's Association of the Paper Industry. CHARLES E. CANFIELD, President, Canfield Paper Co., New York, N. Y., and Treasurer, National Paper Trade Association.

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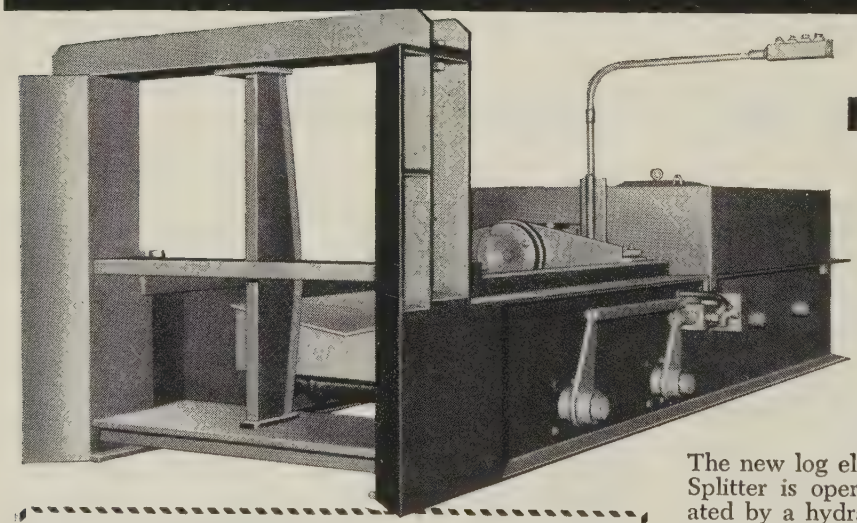

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GENERAL MILLS' pure guar gum *strengthens, improves* surface of many grades of paper.

1 ***kraft liner board*** — here GUARTEC improves mullen. Frequently faster machine speeds and less refining are extra advantages.

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3 ***corrugating medium*** – GUARTEC gives increased stiffness, and is particularly successful in waste paper furnish grades.

4 ***book paper*** — including ground wood printing, rotogravure, and magazine paper—GUARTEC improves surface, formation, fuzz-lay-down, printability and clay retention.

5 ***fine paper*** — as in book paper, GUARTEC shows a marked improvement in surface and formation characteristics, and can provide economical *clay retention.*

6 ***multi-wall bag paper*** – GUARTEC can offer higher tensile strength with no real loss of tear strength! It also improves porosity of multi-wall bag paper.

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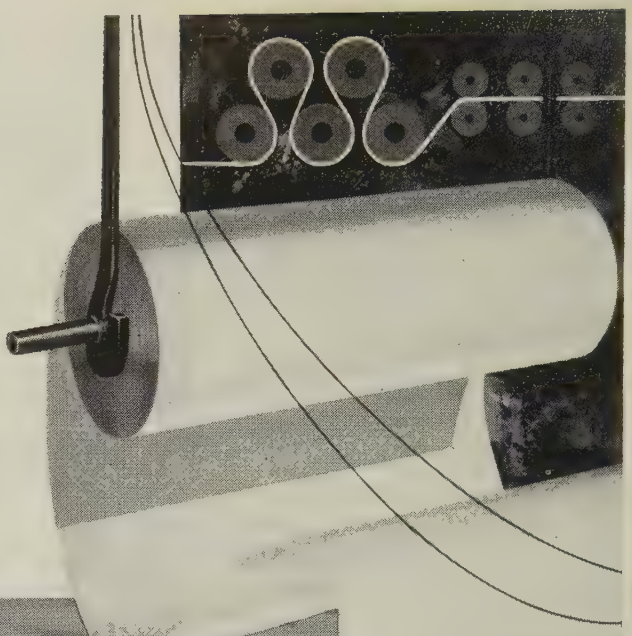
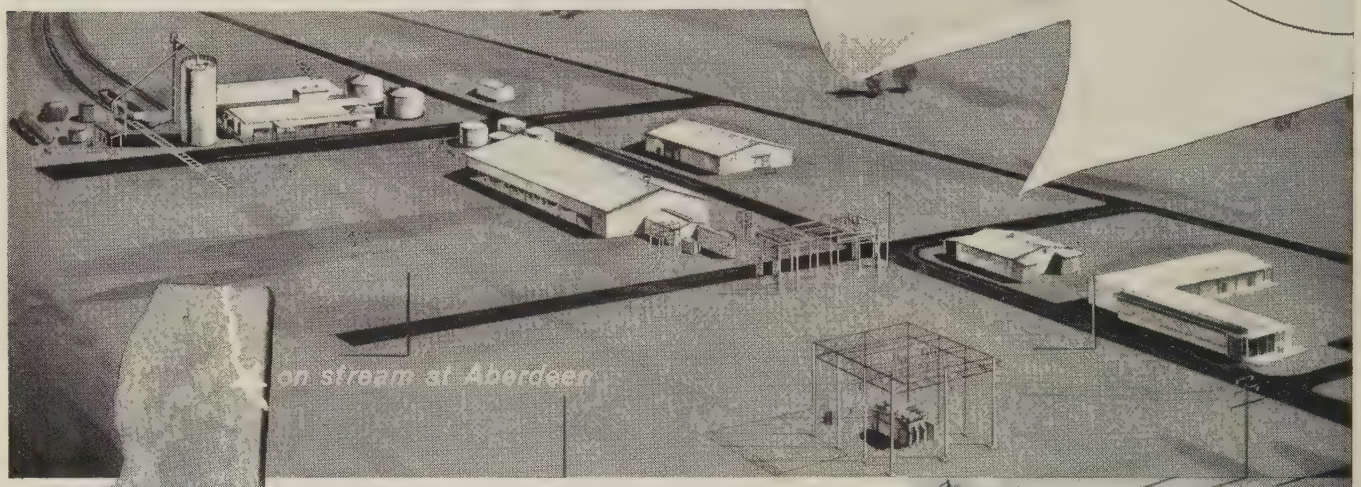
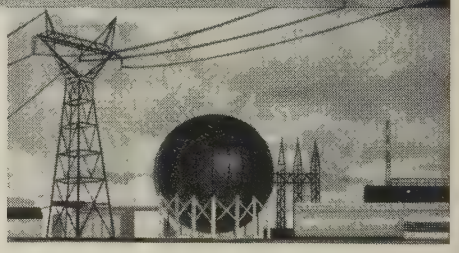




expanded capacity for growing markets by the *largest* domestic producer of $NaClO_3$



The big news in sodium chlorate is TRONA's new electrochemical plant, now on stream at Aberdeen, Mississippi. This latest AP&CC facility provides faster and better service to the South's growing pulp and paper production centers, as well as further assurance of dependable sodium chlorate supply for other important markets in such fields as agriculture, uranium ore processing and solid propellant fuels. Aberdeen's readily expandable, initial capacity of 15,000 tons per year, added to the $NaClO_3$ production capability of Trona's Henderson, Nevada, plant makes American Potash & Chemical Corporation the largest domestic supplier of sodium chlorate... capable of meeting *all demands* from expanding commercial and military users. *Further information on Trona's sodium chlorate service and production capabilities at Aberdeen is available from your nearest AP&CC branch office.*

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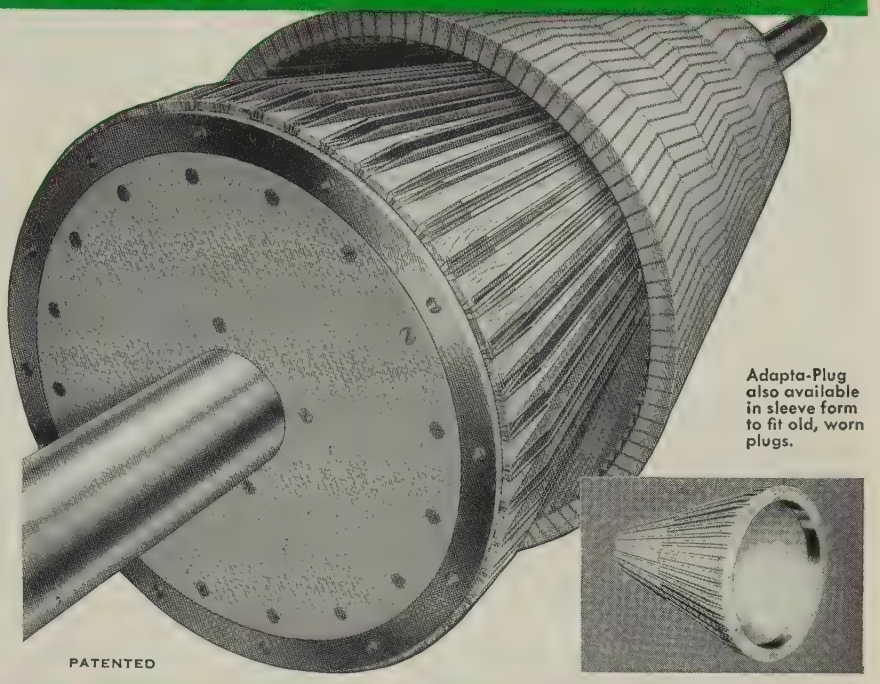
Many mills report spectacular savings for stripping and filling this completely bandless plug. Inverted-wedge-type slots hold bars more securely, eliminate slot wear and corrosion. Exclusive Nowave design assures precise alignment, closer contact, straighter bar wear, longer filling life, accurate plug settings, and better, more uniform refining. For full details on Jones Adapta-Plug send for Bulletin EDJ-1094 and 1094A.



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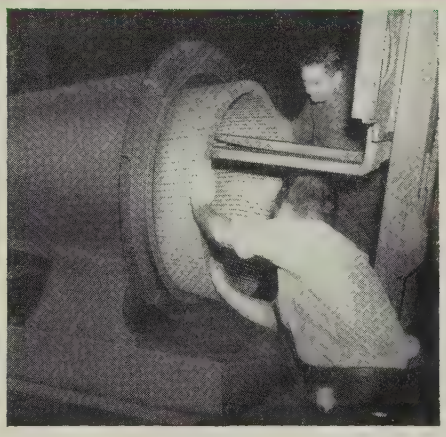
Adapta-Plug also available in sleeve form to fit old, worn plugs.

AND FULBAR SHELL FILLINGS

Fulbar one-piece construction cuts installation time, often by hours.



Unlike sectional fillings, rigid Fulbar readily compensates for inequalities in old shell body.

Jones Fulbar fillings are available in *any* bar combination for *any* make of Jordan. Their rigidity and accuracy eliminate the need for keys and wedges. They are far easier to install, easier to grind in —and the patented Nowave pattern offers no sharp bar ends to form strings or lumps. For full details, send for Bulletin EDJ-1094.

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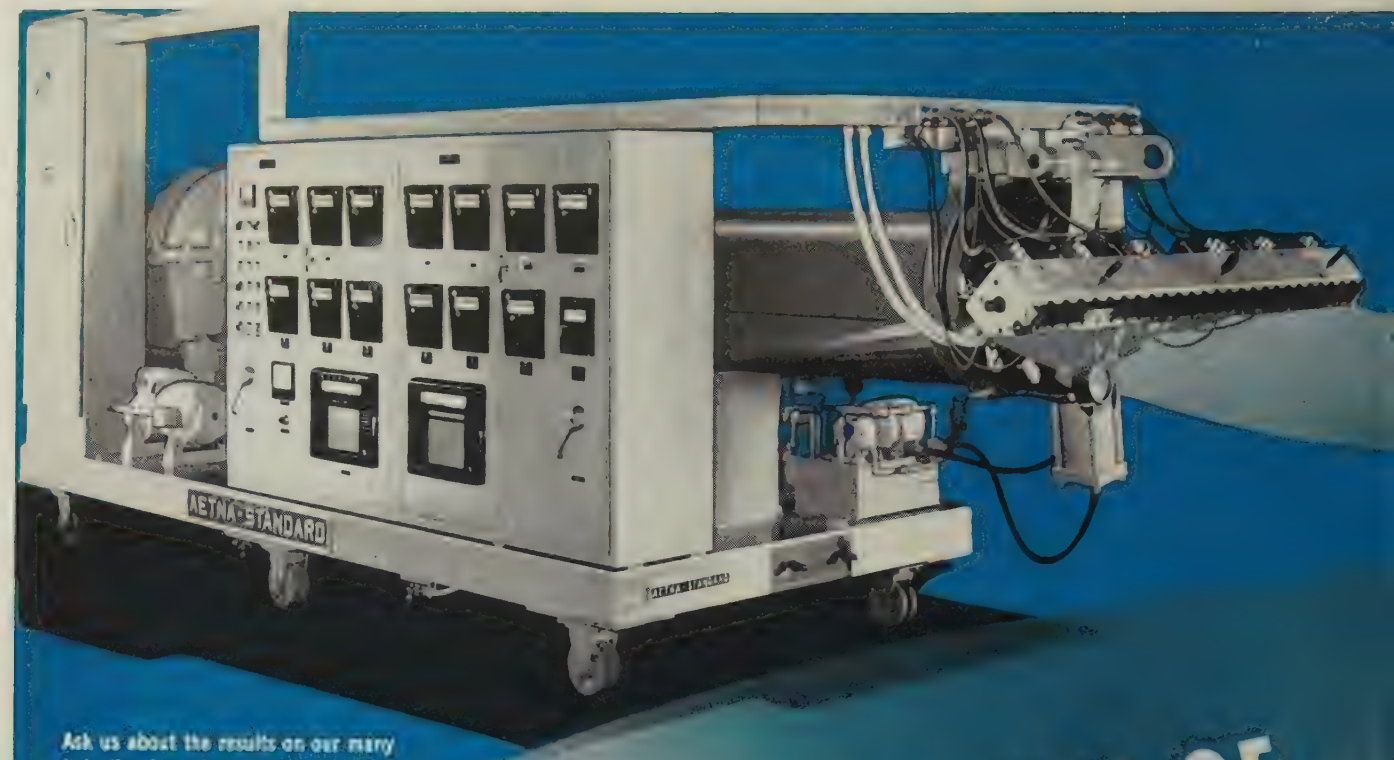

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UNITIZED CONSTRUCTION . . . Just set it on the rails and connect the power supply.

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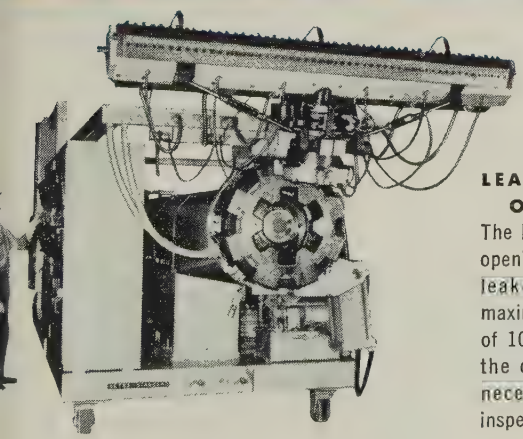

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The breech-lock-type, quick opening die adapter assures leak-proof sealing at the maximum design pressures of 10,000 p. s. i., plus all the quick opening features necessary for screen pack inspection.

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Tall Oil in Synthetic Detergents

TALL oil products of all kinds now go into the manufacture of a wide range of synthetic detergents. Whole (crude) tall oils, tall oils refined by solvents (acid refined) or by distillation (distilled), as well as tall oil fatty acids and tall oil rosin are all important ingredients. The requirements for syndets are often highly specialized and tall oil processors have perfected many novel operations to meet such needs. The successful marketing of tall oil products into the fast-moving, highly technical detergents industry is due in large measure to the continued willingness and ability of tall oil producers to help solve the apparently unending stream of problems that comes with new products.

SYNDETS MARKET

Synthetic detergent manufacturers celebrated in 1958 the 25th anniversary of the first American synthetic household detergent, Procter and Gamble's "Dreft" (*62*). Today over 200 brands compete in the huge market for household syndets of this type alone. There are now well over a thousand brands in all, with no sign of a slackening in offerings of new compositions and new uses.

Much of syndets growth has been at the expense of soaps. Syndets appear to outperform soaps so far as such matters can be tested (*49*) and in 1957 syndet sales were over 70% of all detergents including soaps, figured in dollars or in pounds (*61*). Syndets are also able to do an increasing number of jobs for which soap was never used. The evidence is all around us in the form of many new products that improve not only our daily living but also many industrial operations. In consequence syndet sales are now increasing much more rapidly than the decline in soap sales.

Thus, according to data from the Association of American Soap and Glycerine Producers, Inc., soap sales dropped but syndet sales gained twice as much during the past five years.

Sales—Billion pounds

	Soaps	*Syndets*	*Total*
1952	2.2	1.8	4.0
1957	1.4	3.5	4.9
Change	−0.8	+1.7	+0.9

The foregoing figures refer to the weights, as sold, and this includes the considerable amounts of builders and other chemicals added to the actual syndets. The amount of 100% active syndet averages about 21% of the product according to one estimate (*19*). Accordingly, the 3.5 billions of products contained only 0.7 billion lb. of 100% syndet. The United States Tariff Commission reports sales, in 1957, of 1.2 billion lb. of surface active agents on a 100% basis. This leaves 0.5 billion lb. for uses not included in the data of the Association of American Soap and Glycerine Producers. However, more concordant versions of the data have been attempted (*54*). There is a good likelihood that many new industrial uses for surface active materials have come in.

The attractive opportunities for users of tall oil products in this market become clearer on reviewing the principal kinds of syndets.

SYNDET TYPES

Syndets are now available in many forms—solids, powders, liquids, and pastes. Generally they are carefully formulated mixtures of organic chemicals having surface active properties—the actual syndets-and of inorganic chemicals—builders—to increase their activity. Minor amounts of other ingredients are also incorporated to modify various properties.

The actual syndets are surface active materials whose molecules have parts that differ strongly in their attraction to water molecules. Thus, one part will cling to water molecules, another part may repel water molecules and prefer to cling to oil molecules. Greek names were devised for this, *hydrophilic* (water loving) and *hydrophobic* (water fearing) or *lyophilic* (oil loving).

Soaps act in this way too; the fatty acid part of a soap molecule is hydrophobic, the sodium part is hydrophilic. In consequence a soap molecule clings to both oil and water and, in the presence of soap, oil can be dispersed in water. This dispersive action is one of the important aspects of the well known but very complicated action we all know as "washing."

With syndets the activities of the parts of a molecule can be controlled by tailoring the molecule. Chemists can now fashion molecules with parts specially devised and arranged. Syndet molecules are being designed on paper to give predictable performance when manufactured.

There are many aspects to the performance that might be required, especially in industrial detergents. The requirements might center on any of many properties such as the ability to cause liquids to wet solids; to disperse solid particles in liquids; to disperse nonmiscible liquids; to dissolve, or be dissolved, in hot water, cold water, solvents or oils; to disperse air or gases in liquids.

THE IONICS

Soap owes its effectiveness in large part to the ability of its molecules to ionize, or to separate into ions of fatty parts attracted to oils and into ions of sodium attracted to water. A large number of syndets also ionize. Most, like soap, form negatively charged, hydrophobic ions, *anions*, attractive to oils. These are classed as *anionic* detergents. Other syndets can be made to form positively charged, hydrophobic ions, *cations*, attractive to oils; they are termed *cationic* detergents.

Reprinted from Tall Oil in industry, Bulletin No. 18, published by the Tall Oil Products Division of the Pulp Chemicals Assn., 122 East 42nd St., New York 17, N. Y.

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Special Products for the Paper Industry . . .

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ACRI-FLO® 151

Specifications

Total Solids Content	47 ± 1.0
pH	8.0 ± 0.5
Surface Tension	30-36 dynes/cm.
Viscosity (Brookfield at 25°)	150 ± 50
Mechanical Stability	Excellent

Physical Properties

Specific Gravity	1.01
Weight/gal.	8.43 pounds
Refractive index (D^{25C})	1.530
Film properties	Clear and glossy
Adhesion	Excellent
Particle size	900 Angstroms 0.09 Microns

GEN-FLO® 62 styrene-butadiene latex for casein or starch coating formulations

Specifications

TSC, % by weight	48 ± 1.0
pH	10 ± 1
Surface Tension (dynes/cm)	28-32
Residual styrene, %	0.05 max.
Brookfield Viscosity, cps	15-25
Mechanical Stability	0.1 max 100 mesh screen

Adds these ADVANTAGES

- Superior brightness
- Better pick resistance
- Higher ink receptivity
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Lbs/gal—Latex	8.45
Specific Gravity—solids	1.02
Lbs/gal—solids	8.51
Particle size—Angstroms—1500-1800	
Dilutibility with water	infinite
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Chemical Division GENERAL THE GENERAL TIRE & RUBBER CO. GEN-FLO®

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CHEMICAL DIVISION • AKRON, OHIO

Creating Progress Through Chemistry

Anionic detergents are by far the largest class. Cationic detergents are sold in much smaller volume; they are more costly to produce but are valued for their special properties.

NONIONICS

The ionization of detergents makes them capable of reacting with some of the impurities commonly found in water or in the soiled objects to be washed. Such reactions often reduce their effectiveness.

The fastest market growth among syndets is being exhibited by a newer type of surface active material. Its molecules do not ionize and such syndets are termed *nonionic*. They are not only excellent detergents but do not react with the common impurities in water. Also, where mixtures of anionics and cationics work against each other, the nonionics are compatible with either of these.

SYNDET MATERIALS

There are now so many raw materials for syndets that, more and more, price governs their share of the market. The search for lower costs and abundant, steady supplies has led many researchers to tall oil and its products. There is also a growing list of tall oil products to choose from, with supplies to increase for many years to come.

Whole tall oil is used for many syndets where its low cost outweighs its dark color and characteristic odor. Various grades of refined tall oils are used where the mixture of rosin acids and fatty acids is preferred. Tall oil rosin is favored for some uses. Many syndets are based on tall oil fatty acids.

As the hydrophobic part of detergent molecules tall oil products face competition, not so much from other industrial fats and oils, as from petroleum based chemicals such as detergent alkylate, dodecyl benzene, and other petroleum materials of less specific compositions. Dodecyl benzene alone is the largest single source of hydrophobic material for syndets; American consumption for syndets was 360 million pounds in 1957 (*21*).

Tall oil and its products can be hydrogenated to alcohols, esterified with many alcohols, dimerized or processed in other ways to increase their utility in syndets.

SYNDET PRODUCTS

The three main types of syndets are each represented by a number of chemical types.

The anionics made today are nearly all sulphated or sulphonated molecules. The principal types are: alkaryl sulphonates, petroleum sulphonates, fatty alcohol sulphates, sulphated esters, sulphated ethers, sulphonated esters, alkyl sulphates, sulphonated amides.

According to the United States Tariff Commission the total of these materials used for syndets in 1957 came to 909 million lb.

The next largest class is the nonionic, consisting mainly of polyoxyethylene polymers. These materials are derivatives of ethylene oxide, and are principally: cyclic esters, acyclic esters, cyclic ethers, acyclic ethers, substituted amines, thioethers.

According to the Tariff Commission in 1957 the consumption for syndets was 84 million lb. of cyclic esters and ethers, 134 million lb. of acyclic esters and ethers, 79 million lb. of nitrogen containing acyclics; a total of 297 million lb. for nonionic syndets.

The cationics are by far the smallest class. They are mainly quaternary ammonium derivatives.

POLYOXYETHYLENES

The biggest use for tall oil and its products in syndets is for nonionics based on ethylene oxide. At least 50% of the 134 million lb. of nonionic acyclic esters and ethers reported made in 1957 by the Tariff Commission were based on tall oil products. The nonionic tall oil syndet is about 35% tall oil, 65% ethylene oxide, so that about 20 million lb. of tall oil products were so consumed in 1957.

The polyoxyethylene tall oil syndets are sold mostly for household use as powders containing 20 to 25% of the actual syndet with the balance being builders such as sodium phosphates, silicates, carbonates, borates and sulphates (*30, 31, 32, 48, 66*). Small proportions of an antiflocculent such as a soluble cellulose are also included along with other additives to modify the color, flow, and other properties. Most of the common polyoxyethylene based syndets are waxy solids of low melting points. Various expedients have been devised to minimize caking when the syndets are blended with the dry builders. Generally these are in the form of suitable absorbents (*6, 25, 66*) or of chemicals like urea which do not seem to impair detergency (*3, 8, 26*).

Polyoxyethylene syndets result when organic molecules with sufficiently strong hydrophobic groups and also an active hydrogen are reacted with ethylene oxide. The ethylene oxide forms a polyoxyethylene chain with one end having a hydroxyl group and the other linked to the hydrophobic molecule (*35, 67*).

Thus, the fatty and rosin acids of tall oil link as esters with the polyoxyethylene chain.

If the tall oil acids are first reduced to their alcohols and then polymerized with ethylene oxide, the tall oil alcohols link as ethers with the polyoxyethylene chains. The extra step of reducing to the alcohols, while adding to the cost, also results in syndets which do not hydrolyze with water. This becomes important in formulations like emulsified products, where the syndet remains in water for a long time. In dry formulations or for short time water contact as in washing with alkaline builders, the use of the less expensive ester is quite acceptable.

Molecules other than those of tall oil are used (*36*). Substituted phenols of sufficiently hydrophobic structure, substituted amines, sulphonates, mercaptans and many more are actively seeking their markets. Chemists have been busy devising novel elaborations for special requirements. However, tall oil linked polyoxyethylenes not only give good HLB (hydrophile-lyophile balance) values (*29, 59*) but also provide a good balance between detergency and economy in cost.

Tall oil polyoxyethylene products have become widely accepted as the basis for household detergents (*11*) and they are also finding many industrial applications such as in textile processing and pesticide emulsions.

The many conceivable molecular arrangements will

ACTION!

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take a long time to explore although some substituted forms have been tried without marked advantages being found so far (*44*, *67*). The detergency of ethylene oxide polymers of tall oil improves with the number of ethylene oxide units and appears to reach a maximum in the range of 12 to 14 moles ethylene oxide per mole tall oil (*23*, *45*). The ratio of rosin to fatty acids in tall oil did not appear to be a critical factor (*63*), nor, for that matter, did the precise fatty acid used (*45*). Polymerized with only 1 to 5 moles of ethylene oxide, the tall oil product was found to be useful as a defoamer (*51*, *52*, *55*).

Nonionics are compatible with either anionics or cationics. Tests show that anionics like alkaryl sulphonates have a better detergency when tall oil polyoxyethylenes are added, even when builders are present (*4*). Ordinary soaps of tallow or of coconut oil are likewise improved in hard water service.

The increasing availability of propylene oxide and other higher oxides has heightened interest in their polymers analogous to the polyoxyethylenes (*35*).

ESTERS

Tall oil products esterified with polyols find various applications as surface active agents. For such uses one or more of the polyol hydroxyls are left unesterified to form the hydrophilic part of the molecule. Such esters are nonionic and so, stable and not reactive with impurities.

Glycerol, pentaerythritol, sorbitol and its anhydride sorbitan are esterified with tall oil products with one or more hydroxyls left free. The hydrophilic activity of such hydroxyls can, if desired, be greatly increased by reaction with ethylene oxide and several such products are available. They are especially effective in emulsion formulations (*2*, *3*, *24*).

Polyethylene and polypropylene glycols are also made into the monoesters of tall oils. Polyglycols with molecular weights as high as 6000 are used. Tall oil monoesters of polyethylene glycols of molecular weights in the range of 400 to 600 have optimum surface activity and are effective for oil emulsions. The monoesters in this range are water soluble, the diesters are oil soluble. The surface activity and solubility of such esters are capable of wide adjustment and formulations are available for breaking emulsions as well as for making them.

Since tall oil esters of polyols are nonionic, they are compatible with anionic or cationic syndets and many complex formulations have been developed for special purposes such as for drilling fluids (*7*, *12*, *28*), pesticides (*9*), and many more.

ALCOHOLS

Tall oil, tall oil rosin, and tall oil fatty acids can be reduced to their corresponding alcohols for use in the manufacture of syndets. Such alcohols may be sulphated to make anionics or reacted with ethylene oxide to yield nonionic, stable, ether-linked tall oil polyoxyethylene syndets (*33*, *47*).

The reduction to alcohol may be by reaction of the tall oil acids or their esters with sodium in alcohol (*46*) or by high-pressure hydrogenation (*17*, *20*, *22*, *34*). Reduction with sodium converts the acid group to the alcohol but allows the unsaturated groups to remain. The high-pressure hydrogenation reduces both the acid group and saturates the unsaturated groups. Where esters are used there is less corrosion and alcohol is formed by the hydrolysis of the ester. The high-pressure hydrogenation process uses a copper chromite catalyst at 400 to 450°F. with hydrogen at 3000 to 5000 p.s.i. pressure. Sulphur or other catalyst poisons must be removed in preliminary steps. On a sufficiently large scale the process is less expensive than the sodium process. More tall oil alcohols should soon become available to provide the low cost rosin and fatty alcohols needed for syndets.

SULPHATES AND SULPHONATES

Sulphates and sulphonates of hydrophobic materials are the bases for over half the syndets sold. The great bulk of the hydrophobic material comes from the petroleum industry. The low price of dodecyl benzene, about 12 cents per lb., has enabled it to develop and hold half the syndets market.

Tall oil fatty acids have taken their place among other fatty acids in the manufacture of sulphated fatty acids (*58*). The consumption of these well known products is declining in favor of newer, more effective syndets.

Sulphonation and sulphation are also used to increase the hydrophilic properties of polyoxyethylene polymers and substituted aminoalcohols used for syndets.

Sulphated products are sometimes admixed with nonionics to increase foaming or foam stability. Such mixtures are also considered to have detergencies superior to either alone (*4*, *5*, *27*, *43*).

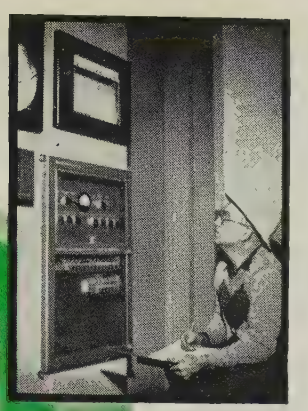
AMINES AND AMIDES

The market for syndets based on nitrogen containing acyclic materials is highly diversified. The addition of nitrogen in the form of amines or amides to the chemists other building blocks provides a much greater scope for novel performances. Were it not for their relatively high costs these syndets are so versatile that they could develop an enormous market. Even so 79 million lb. of such surface active materials were made in 1957.

Tall oil and its products can be converted to amines by heating with ammonia, dehydrating to the nitrile and hydrogenating to the amine (*56*). The amine is treated with ethylene oxide to form polyoxyethylene substituted tertiary amines. These can be esterified with tall oil or other acids, or reacted with alkyl halides to form quaternary ammonium products (*1*, *16*).

Tall oil is also reacted with ethanolamines. Ethylene oxide may be combined with the resulting amide. Such products are used to increase detergency in formulations with other syndets, to control foam and for other surface effects.

Nitrogen based syndets have been found effective for breaking emulsions (*55*, *60*), for bonding asphalt to wet stone (*37–42*, *50*, *65*), for scouring chemical grade wood pulps (*18*, *57*), for drilling fluids (*64*), for emulsions (*10*, *53*) and for the flotation of minerals (*14*, *15*, *17*). There is a great deal of activity in the amine syndet field and in addition to these references to the use of tall oil products, there are many more applications referring to rosin and to other fatty acids under



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conditions which could readily be extended to the use of tall oil products.

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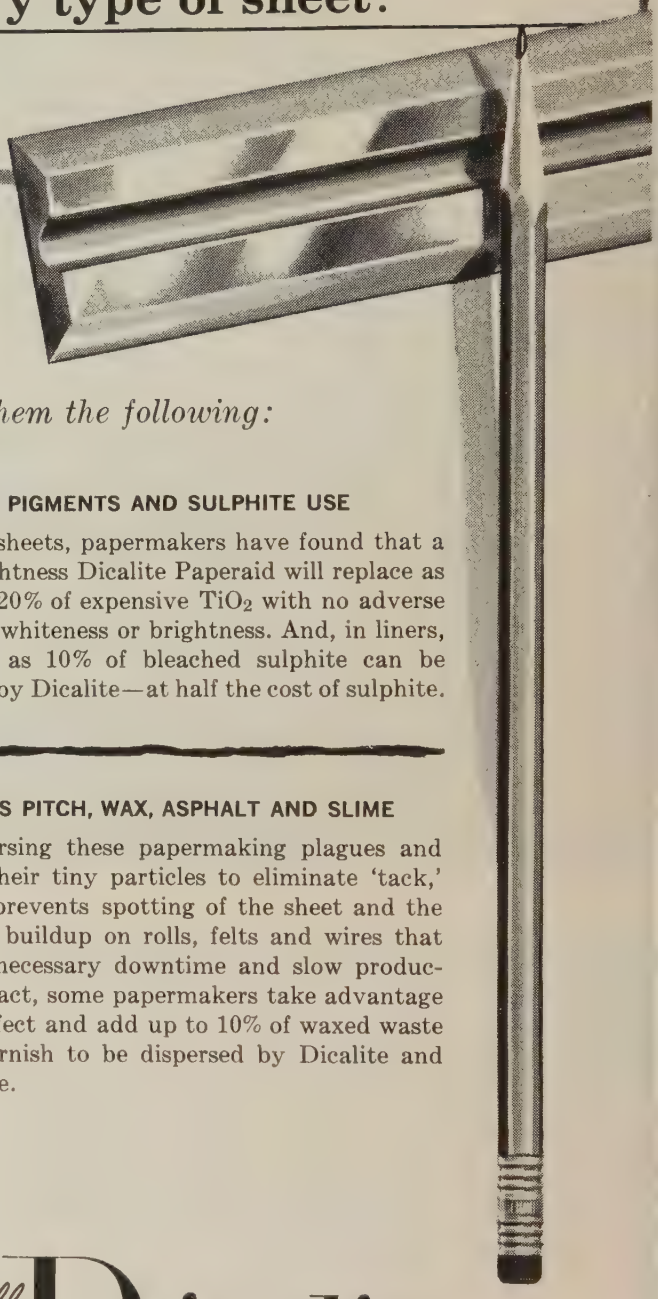

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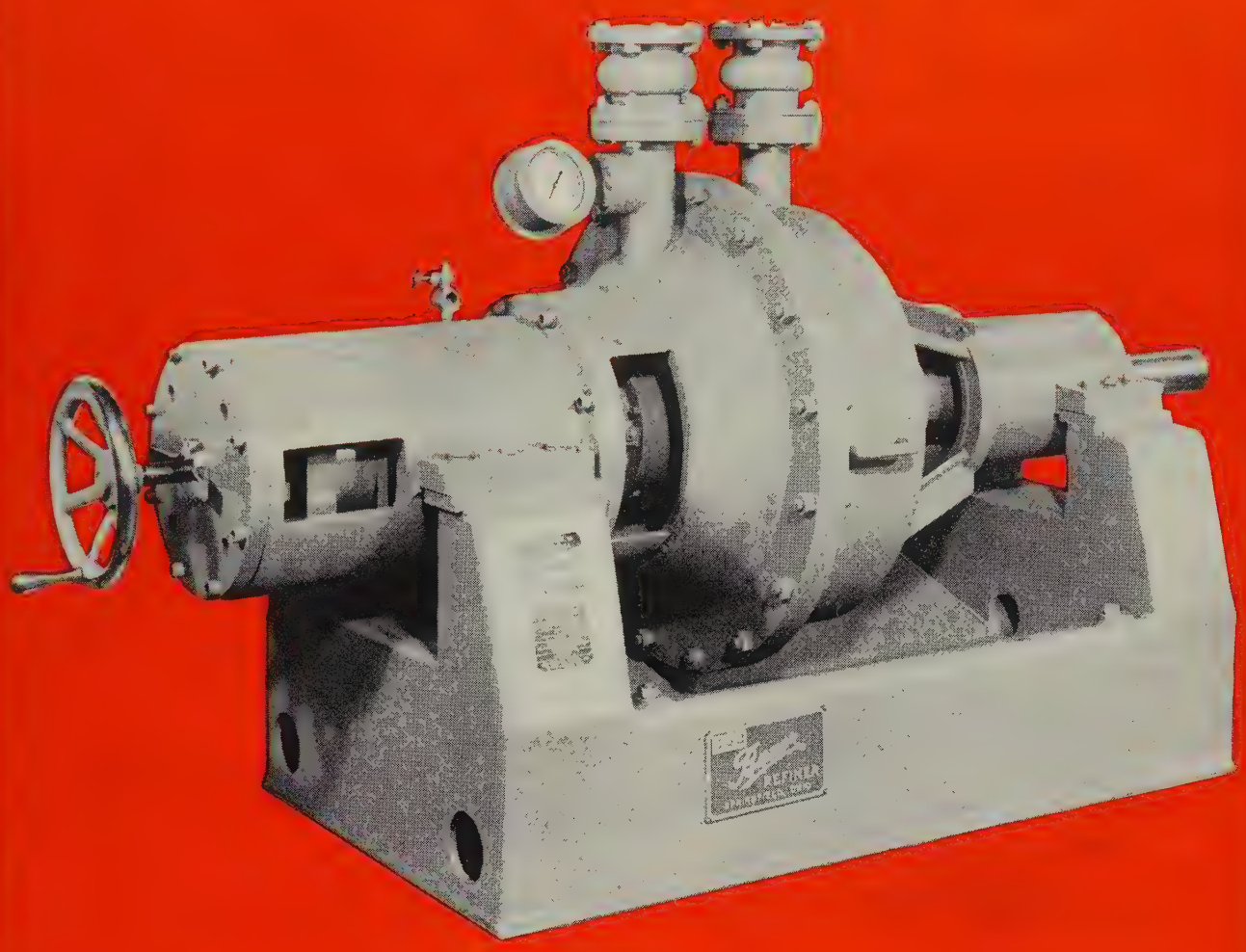

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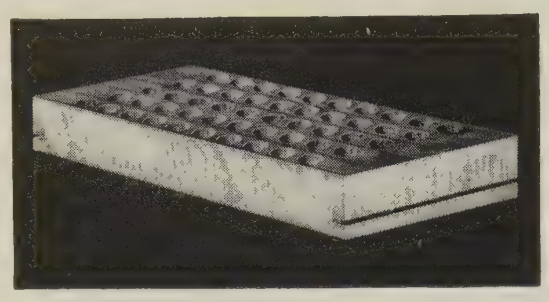

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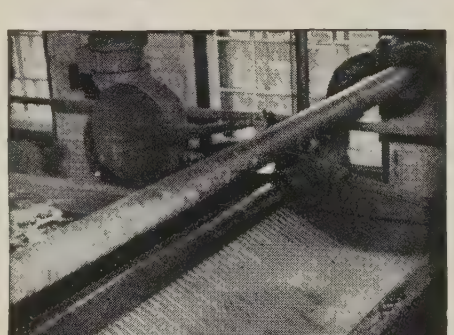

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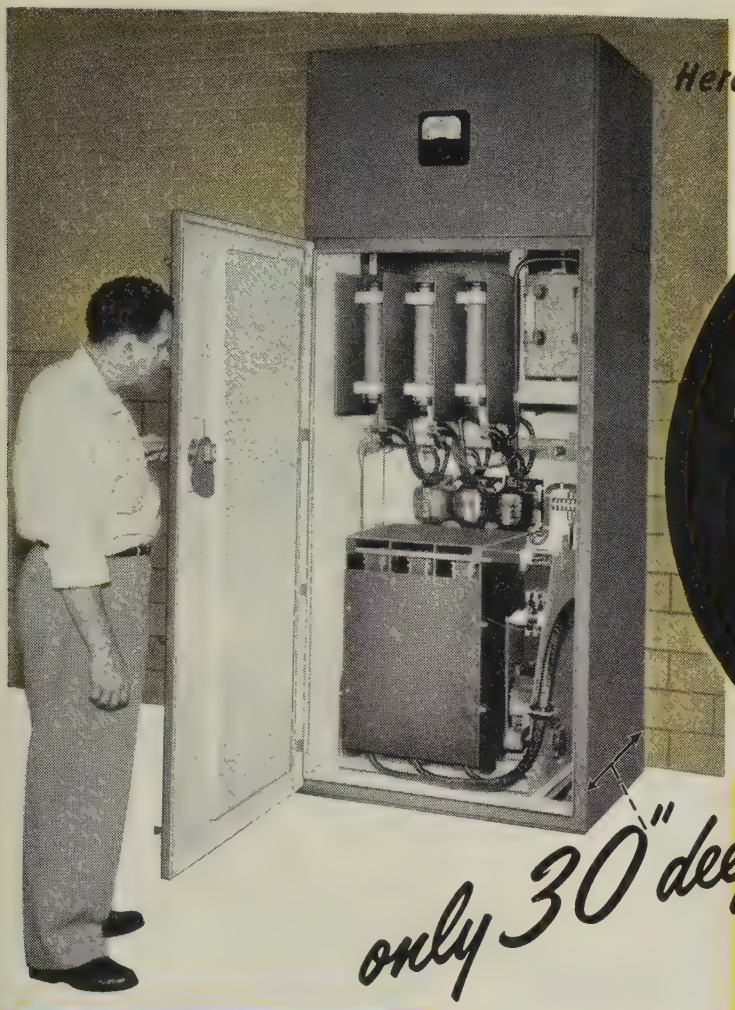

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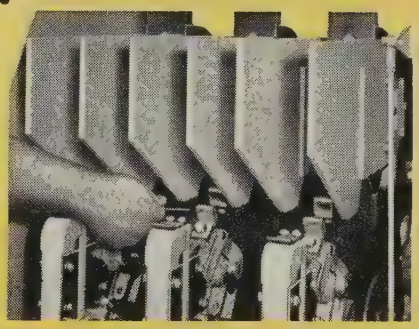

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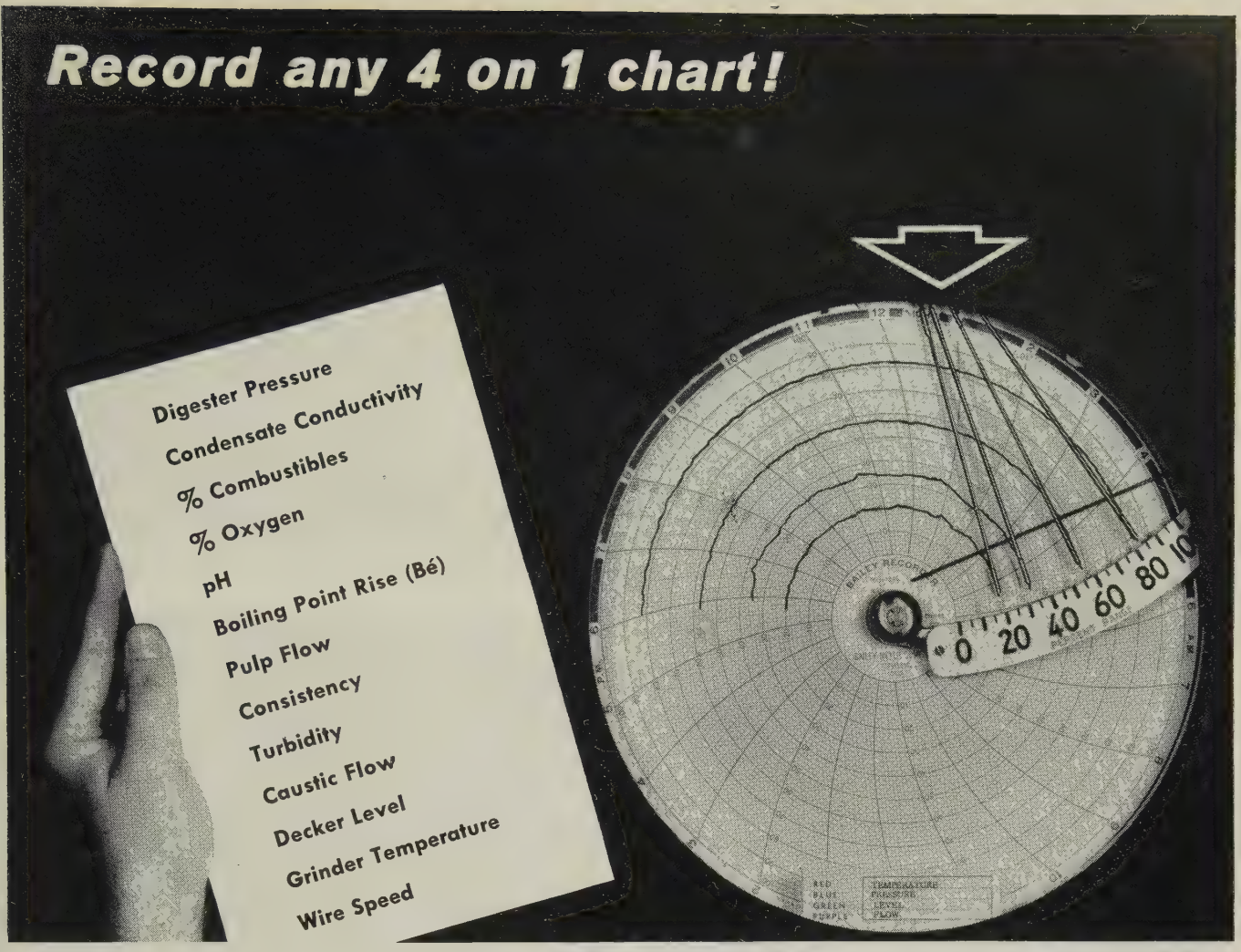

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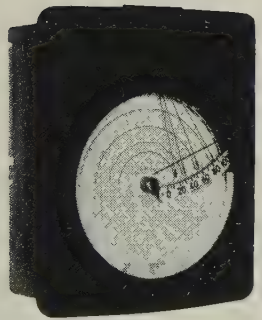

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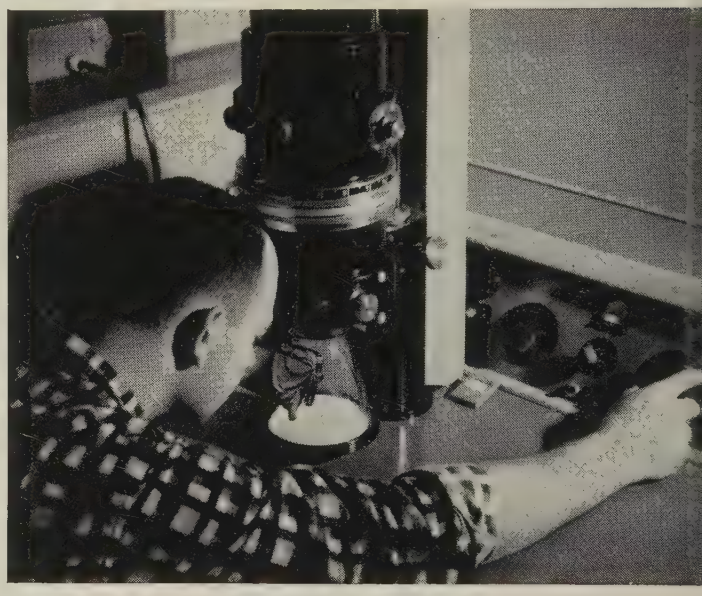
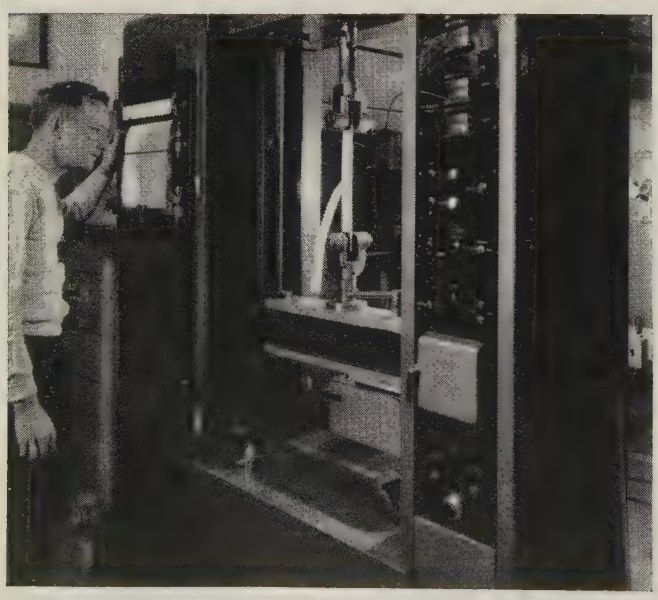
1. Koppers new Kobuta Development Laboratory.

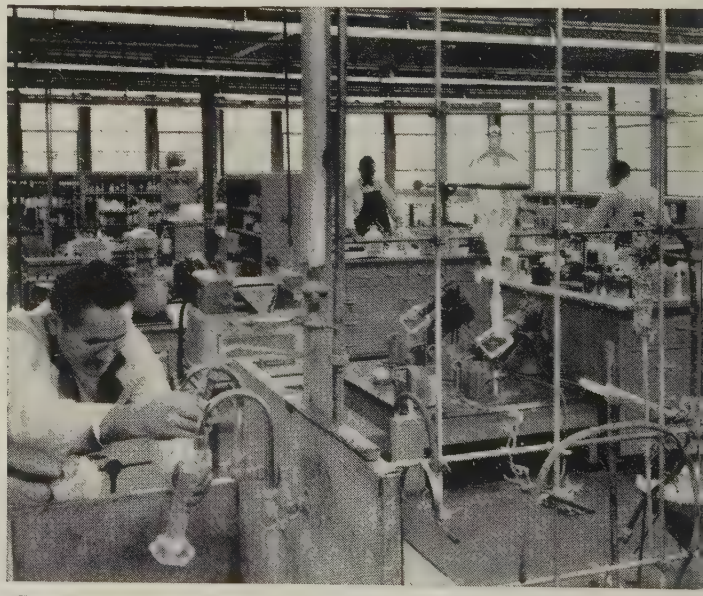
2. Here, coatings made from DYLEX K-52 and a conventional latex take photo comparison test.



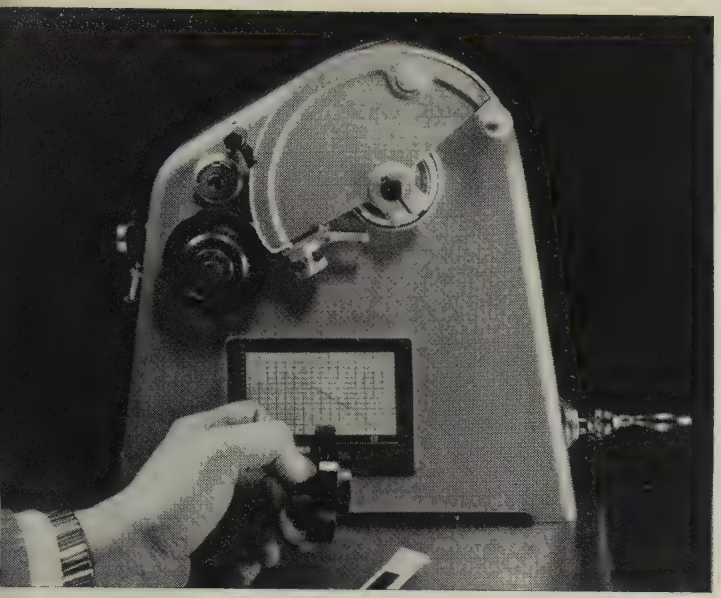
3. Latices are first checked for particle size in the Electron Microscope. Uniformity is essential for fine coatings.



4. The Instron Tester—this instrument measures tensile and flexural strength of coated paper, or films for coated paper.



5. When the coating passes these tests, it's ready for the Paper Applications Laboratory.

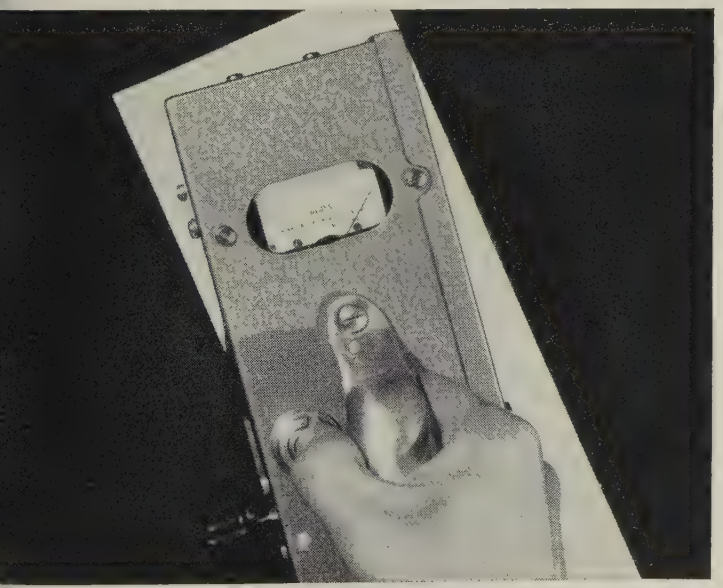


6. The IGT pick test determines the adhesive strength of the coating.

7. The coating is applied to paper in a new experimental paper coater. This machine **actually duplicates** mill conditions.

8. The Tabor Abrasor determines the wet rub resistance of the coating.

9. After the sheets have been calendered and tested for pick resistance, they are checked for smoothness.



10. Here, quality coated paper is carefully checked for gloss.

So far, Koppers extensive research and development program has produced two outstanding paper latices:

DYLEX K-52—for conventional clay coatings.
DYLEX K-85—for specialty papers requiring an extremely high gloss.

And there's more to come.

For more information about how these latices can improve your paper coatings, write to Koppers Company, Inc., Plastics Division, Dept. T-69, Pittsburgh 19, Pennsylvania.

DYLEX is a registered trademark

KOPPERS

Offices in Principal Cities · In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ont.

KOPPERS

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Products for the Pulp and Paper Industry

Centrifugal pumps, rotary compressors, motors, control, Texrope drive equipment, screens, slakers, kilns, turbine-generators, condensers, switchgear, water conditioning equipment, materials handling equipment.

Texrope is an Allis-Chalmers trademark.

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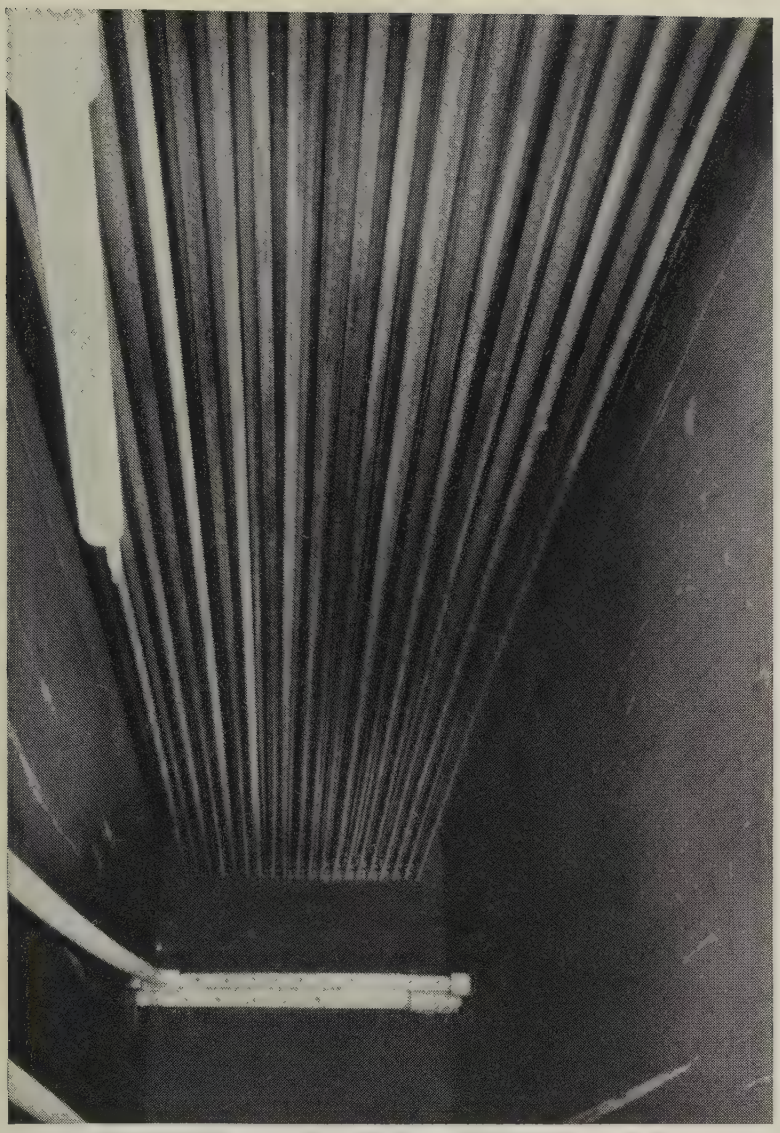


problem:

A chemical company, using a cold water heat exchanger to cool caustic soda and sodium hypochlorite, was being plagued by breakage in the 2″ dia. glass tubing. Shutdowns occurred about three times monthly . . . each time consumed about 15 extra man-hours to change tubes . . . necessitated additional processing of contaminated hypochlorite.

solution:

A heat exchanger was fabricated from Carpenter Titanium Tubing. Ten-foot lengths of this tubing were vertically submerged directly in each caustic soda processing vat.

results:

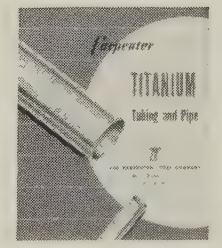
Maintenance costs reduced nearly $1500 annually! No tubing failure since Carpenter Titanium Tubing was installed two years ago! Increased production! Improved product quality! With a heat exchanger in each processing vat instead of separate unit, pumps and pump plumbing previously required to transfer highly corrosive fluid, and maintenance problems connected with them, have been eliminated!

Carpenter Titanium Tubing tames corrosion . . . reduces costs

Why not take advantage of the corrosion and cavitation resistance, light weight and high strength of Carpenter Titanium Tubing? It is the *least expensive* tubing you can use under many corrosion influences. It withstands conditions that reduce service life of ordinary metal . . . assures minimum downtime, fewer replacements.

Three commercial grades—C40, C55 and C70—in tubing sizes up to 4½″ O.D. are available.

In the food, chemical, pulp, paper and allied industries . . . the long, trouble-free service life of Carpenter Titanium Tubing provides countless opportunities to improve equipment performance and to reduce operating and maintenance costs. Contact your local Carpenter representative or distributor for the full story.

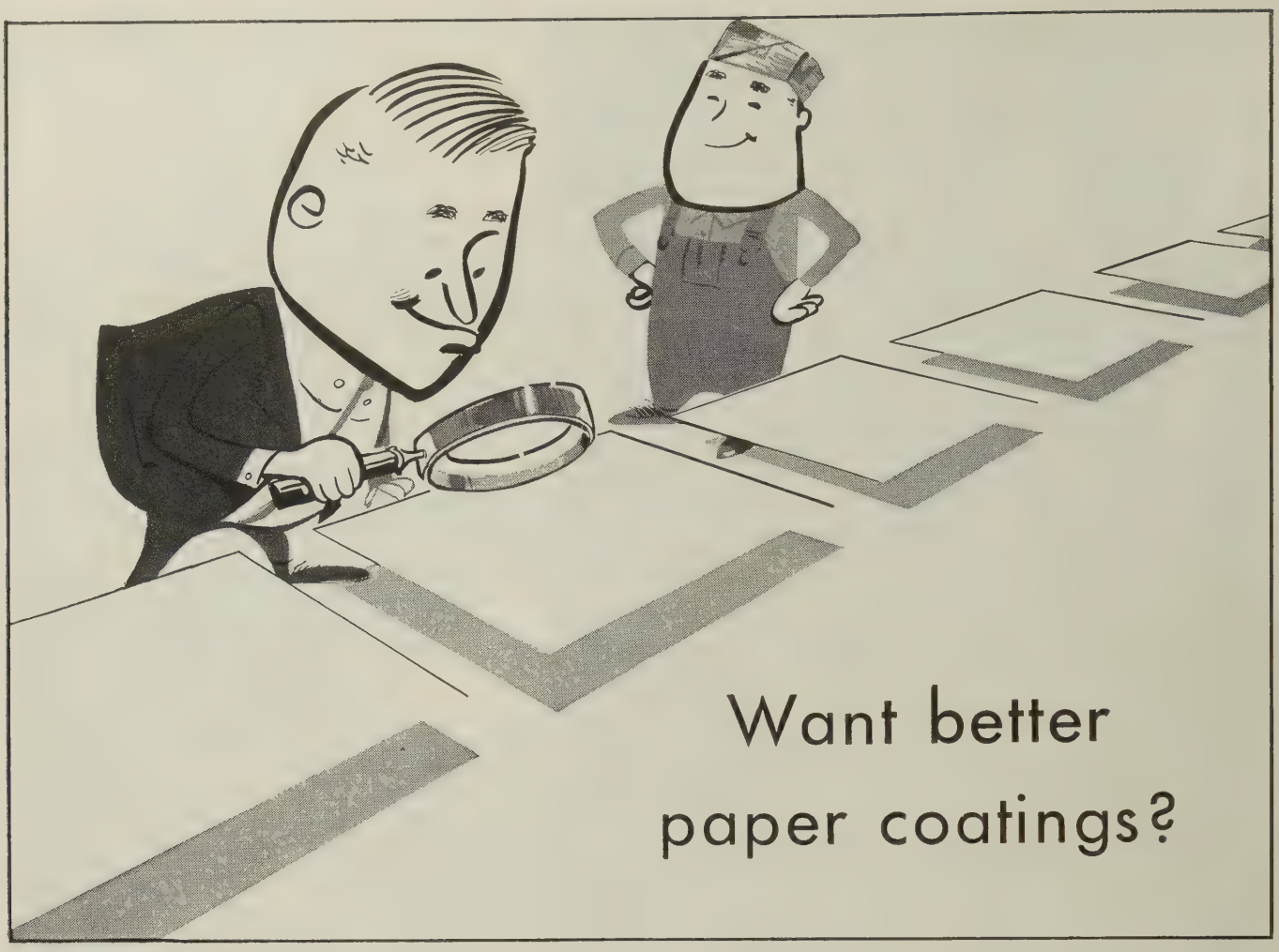


Write for Bulletin T.D. 115A. *Contains complete data on the properties, corrosion resistance and application benefits.*

your master key to cost-saving corrosion control

Carpenter

titanium tubing & pipe



Sample new PURECAL* O

—Wyandotte's *refined* grade of pure calcium carbonate

Get set to profit with better coated stock at competitive prices. Just use Wyandotte's new *Purecal O!*

Precipitated by an exclusive Wyandotte process, new *Purecal O* is the purest of calcium carbonates. Free from discoloring impurities, *Purecal O* is unmatched among coating pigments for whiteness and brightness over the entire range of visible light.

So, contaminant-free *Purecal O* never gives coated papers that "off-white" cast . . . never muddies the sparkle of colors. And *Purecal O* carries no trace of abrasive grit to wear down printing plates before their time; cause expense and delay.

Better check into the advantages of *Purecal O* for yourself . . . for complete technical data and samples to evaluate in your own laboratory, write today: *Wyandotte Chemicals Corporation, Technical Inquiry Section, Wyandotte, Mich. Offices in principal cities.*

QUALITY-CONTROLLED UNIFORMITY

Controlled precipitation insures the same purity and shape and particle size of every pound of new aggregate-free *Purecal O.*

A HIGHER FINISHING $CaCO_3$

Its particle size and freedom from agglomeration give *Purecal O* finer finishing properties vital to high-quality coated stock.

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Loading Tank Cars at one of our mines

...an important phase of TGS Service

This is a service of interest to the rapidly increasing number of companies preferring to receive their sulphur deliveries in molten form so that they can transfer directly from cars into consumption. We are equipped now to deliver molten sulphur by tank car from all mines and recovery plants to any place in the country. Detailed instruction sheets and drawings are available on request for those in the planning stage or who do not have adequate or proper facilities for handling and storing molten sulphur.

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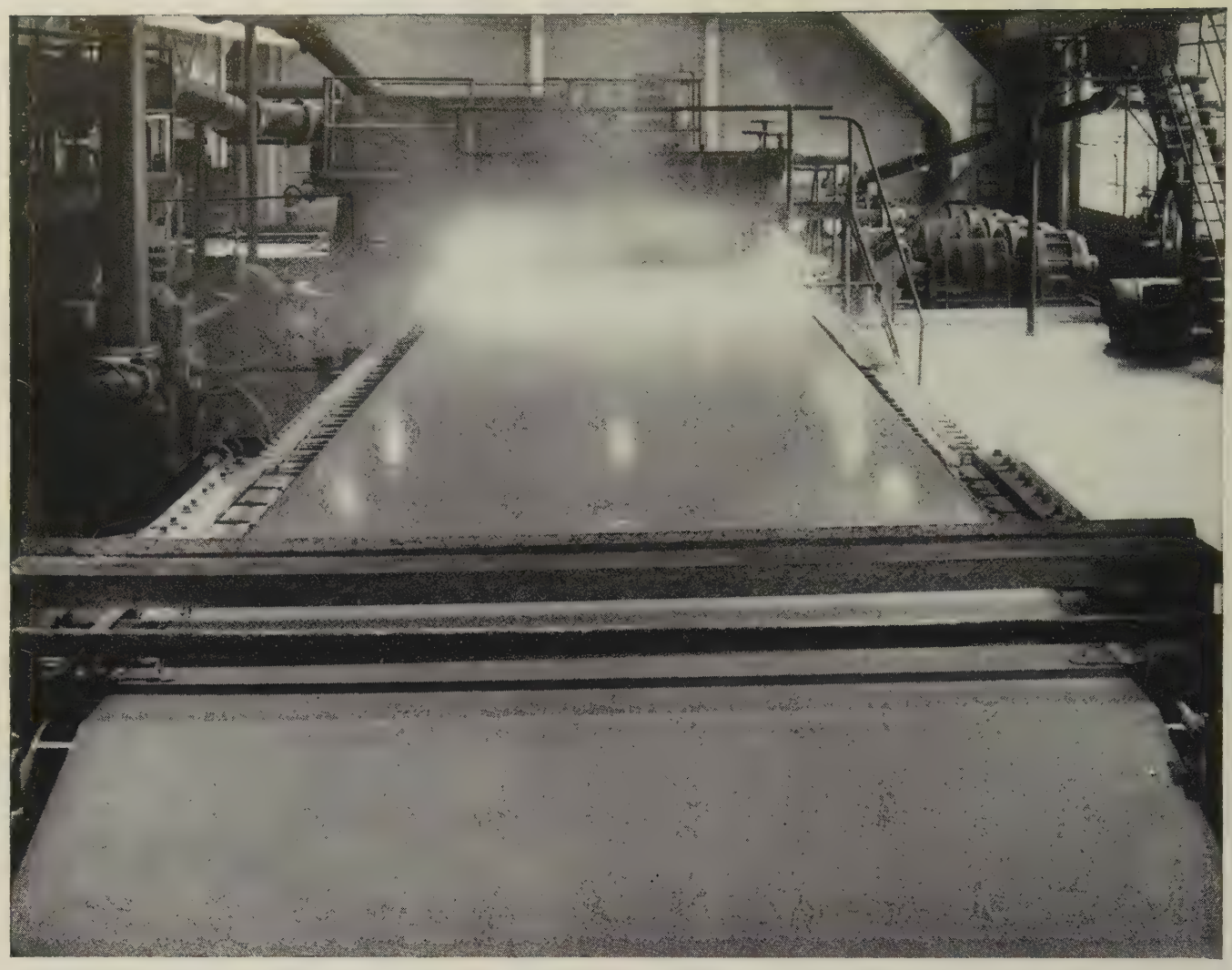

A Complete Starch Line... *tailor-made to your needs*

Today's complex papermaking operations require a wide range of starches—starches specifically designed to do a particular job. You'll find that the complete starch line offered by Corn Products Company includes types for every phase of modern papermaking. These starches are available in so many varieties that *they can literally be tailor-made to suit individual requirements* and production problems of individual plants!

For example, in beater sizing, preferred starches for improved surface qualities plus excellent bursting and tensile strength, include the many varieties of Globe and pre-cooked Amijel. For calendar sizing, you'll find a complete line of Claro and Eagle starches, as well as Globe starches for enzyme conversion. In this operation, Globe and Excello dextrines and thin-boiling Foxhead starches are also used. For general coating, with good viscosity at high solids content, use Claro and new improved Ten-O-Film starches.

And the research staff of Corn Products Company, largest in the industry, is constantly at work developing new products to meet the changing needs of modern papermaking.

Our technical representatives are completely versed in the problems that arise with wet end additives. Their impressive field experience and continuing research into starch, evidenced by frequent publications in trade and technical journals*, is always at your service. Take full advantage of the facilities and experience of the world's largest corn processors—call our nearest sales office or write direct.

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A most fitting background for type

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Here's a new approach to Blue and Green bond and printing papers.

Solophenyl® Blue 8GL

A low cost direct blue with the necessary fastness properties for fine papers.

Paper Bond Blue BP

A low cost Alizarine type blue with rapid developing characteristics and needed properties for high grade printing papers.

Use the above two blues as a base for blue shades or in conjunction with

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Our technical staff will be glad to demonstrate the adaptability of those products.

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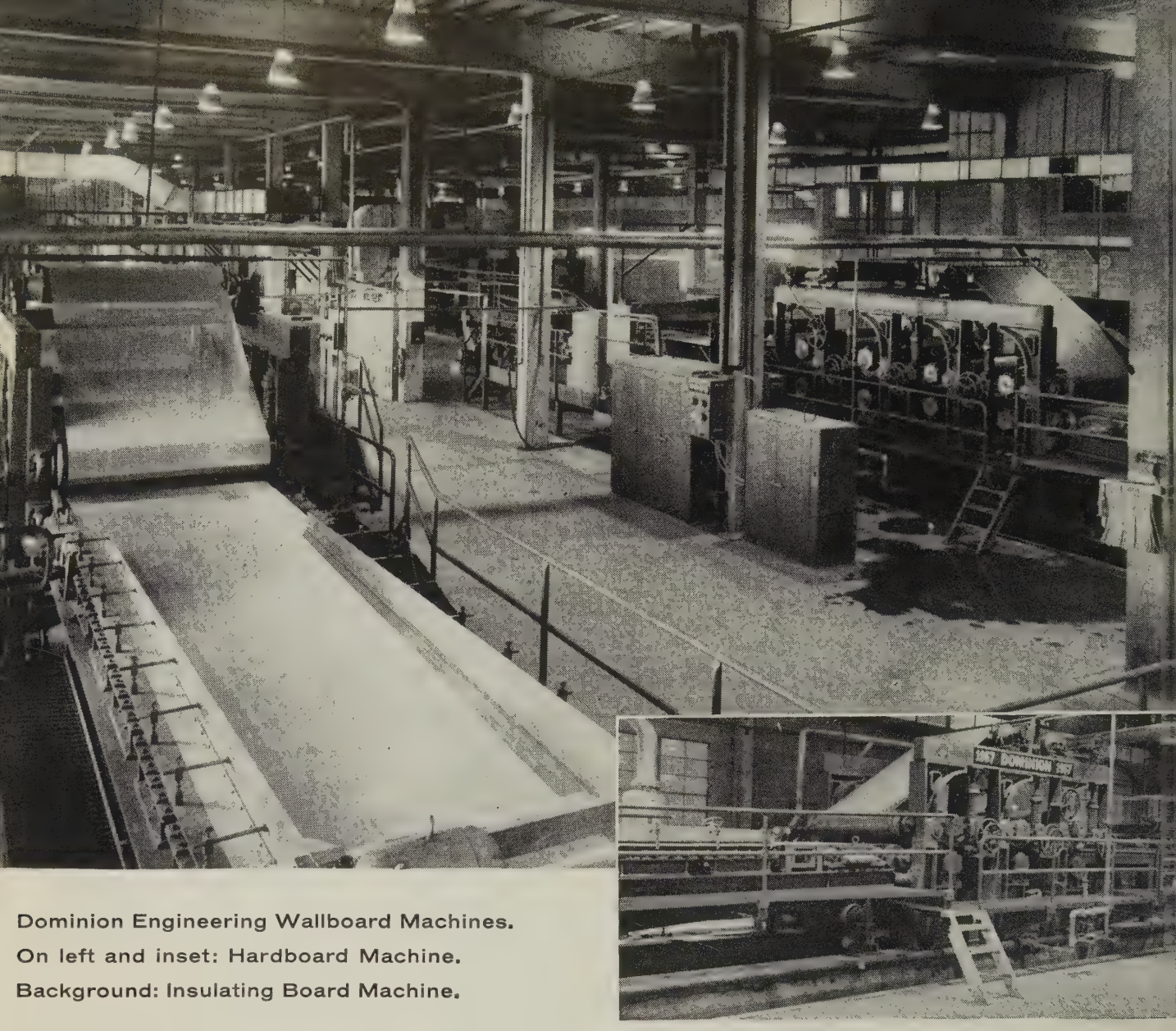

Dominion Engineering Wallboard Machines.
On left and inset: Hardboard Machine.
Background: Insulating Board Machine.

Designed and produced by DOMINION:

Hardboard and Insulating Board Machines, installed at the Saskatoon Mill of the Prairie Fibreboard Company.

DOMINION–Canada's foremost supplier of Pulp, Paper and Board Machines since 1920.

PAPER DIVISION

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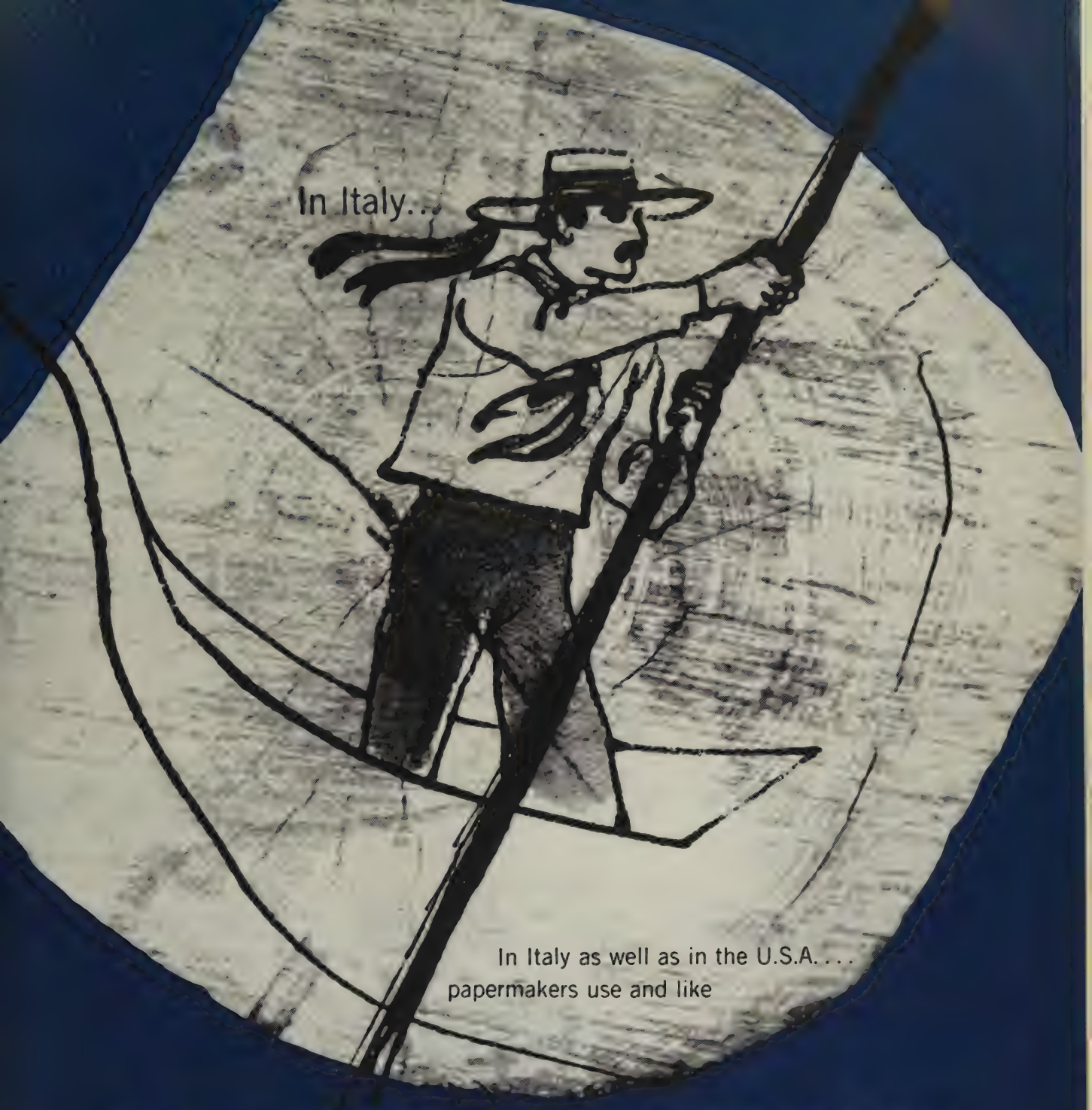

In Italy as well as in the U.S.A. . . .
papermakers use and like

ALBACEL & ASTRACEL

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CHLORINE DIOXIDE BLEACHED HARDWOOD SULPHATE

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Throughout the free world, papermakers use and like Riegel's
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brightness, cleanliness, strength, formability and proper beating characteristics.

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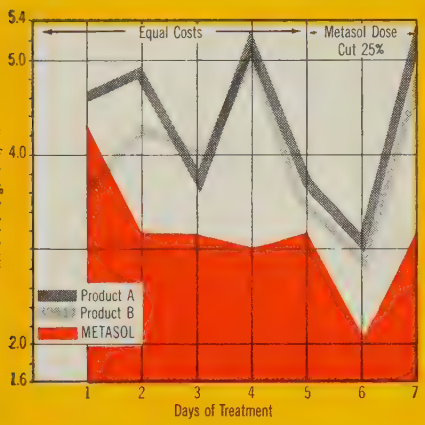
NEW SLIMICIDE EXCELS

METASOL® chosen for regular use

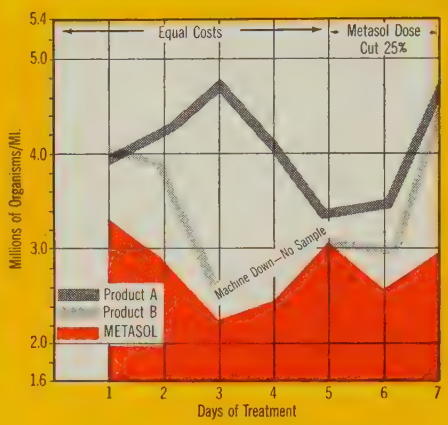
What happened when METASOL was mill-tested against two widely used conventional slimicides

Run parallel at equal prices with results verified by impartial mill engineers



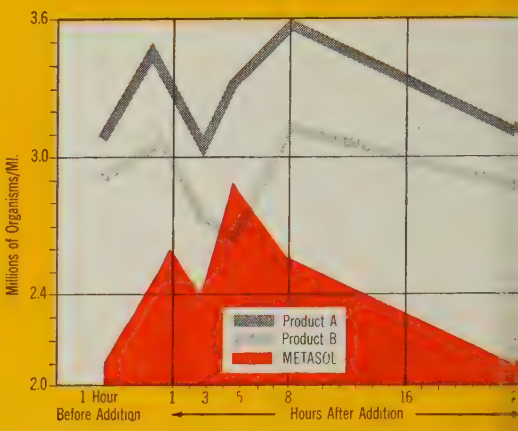
25% to 35% MORE EFFECTIVE QUICK KILL

Daily count of organisms per milliliter over a seven day period, **one hour** after addition of slimicide.



30% to 40% MORE EFFECTIVE SUSTAINED KILL

Daily count of organisms per milliliter over a seven day period, **23 hours** after addition of slimicide



25% to 30% MORE EFFECTIVE AVERAGE KILL

Daily count per milliliter on hourly basis, from one hour before addition of slimicide to 23 hours after.

The same conclusive result from tests at three leading mills

METASOL compared with conventional slimicide

In this bleached-kraft, hardwood pulp mill, solid METASOL replaced a solid conventional slimicide on an equal cost basis. Schedule for both slimicides was three times a day, at eight-hour intervals. All exposed parts, both wood and stainless steel, had been slime-coated when previous slimicide had been used. METASOL cleaned them after the first run.

Compared with a second machine, in which no slimicide was used, the METASOL-treated machine showed an organism count only half as high, even though the no-slimicide machine was washed down 7 to 15 times as frequently as the METASOL unit. The low count was maintained throughout six months of continuous use.

METASOL in ground wood

METASOL was tested against two conventional slimicides in a newsprint mill using a mixture of ground wood and sulphite pulp. All three were run parallel at equal prices.

After only a few days, METASOL showed a far superior level of protection. At the request of mill management, the METASOL dose was dropped 25% in cost below the other two slimicides. METASOL continued to show a superior rate of protection and, over a two-week period, built up still more protection, then leveled off evenly. Over a three-week period, the machine using METASOL had higher productivity, no sign of microbiological slime break, and a much lower organism level.

METASOL in comparative performance test

In a test at a bleached-kraft mill, one machine was treated with solid METASOL and the other with a solid conventional slimicide on an equal cost basis. At the start of the test, both machines showed a count of 4,000 organisms per milliliter. After 24 hours, the machine using the conventional slimicide showed a slime build up. Consequently, the METASOL treatment was reduced one-third.

At the end of a week, the count on the machine using METASOL had been cut to 2,000 per milliliter, while the count on the other machine had built up to 12,000 organisms per milliliter. In addition, the machine treated with METASOL had produced 17% more paper.

METASOL®

SLIMICIDES

IN MILL TESTS
after successful trials

MILLS GIVE METASOL® HIGHEST RATING!

- Most complete slimicidal action
- Most economical
- Highest, fastest solubility in water
- Odorless
- Colorless
- Harmless to equipment
- Minimum deactivation
- Sustained effectiveness
- Thoroughly field-proved

Scores on dollar-efficiency basis
Gives around-the-clock protection

ETASOL is a completely new type of slimicide. It has een developed after seven years of research, during hich it was evaluated against almost 2,000 other mpounds, including all conventional formulations.

horoughly tested by leading mills, METASOL has een found superior to any other slimicide on the mar- et. Every mill which has tried it has decided to use it n a continuing basis.

Keeps machines running

ETASOL lowers production costs because it keeps achines clean and helps them deliver a finer product ithout loss of time. One mill which previously had to hut down weekends for wash-downs now runs five con- nuous weeks without a shut down. Daily production as gone up also.

Protects against all organisms

f all commercial products tested, this new slimicide rovides the most effective "quick kill" and "sustained ill" action against bacteria, fungi and other micro- rganisms. It is so effective that doses can be reduced ubstantially compared with conventional slimicides, and still produce better results. Furthermore, tests show that, unlike other slimicides, METASOL does *not* permit microorganisms to develop resistance.

Lowest cost

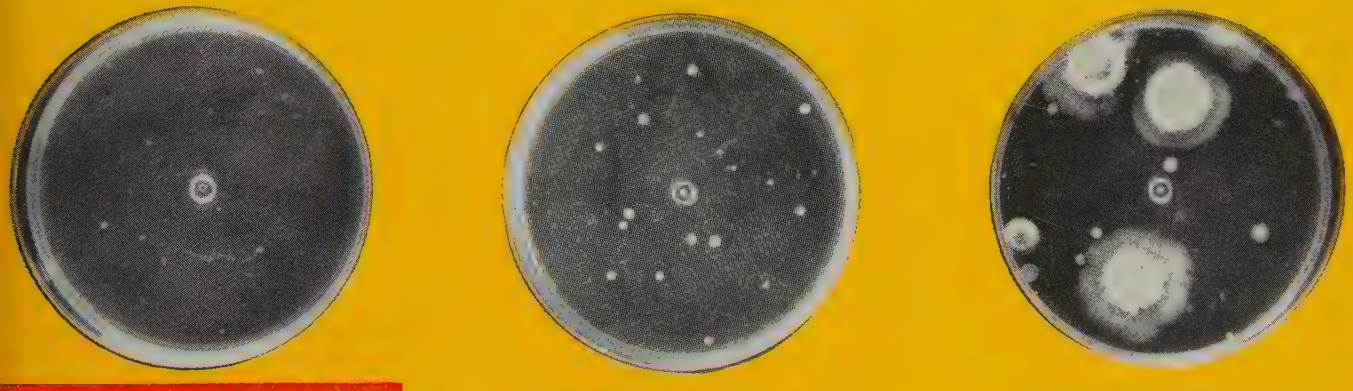
METASOL is the most economical slimicide you can buy. It costs far less per-effective-dose. It has the highest and fastest solubility in water. You can use it in dry (METASOL-P) or liquid (METASOL-L) form, whichever your particular mill situation may require.

Demonstration in your mill

METASOL chemists and micro-biologists will demonstrate its effectiveness in your mill, on your machines, under normal production conditions. On request, they will analyze your particular slime problem, recommend corrective and preventive measures, and train members of your own organization in efficient slime-control methods.

Use the coupon on the bottom of this page to ask for your copy of a new brochure which shows exactly how METASOL slimicide works, and actual comparative performance records under mill-run conditions.

21 DAY TEST SHOWS SUSTAINED KILL



METASOL

PRODUCT "A"

PRODUCT "B"

METASOL DIVISION
Metalsalts Corporation
200 Wagaraw Road
Hawthorne, New Jersey

In Canada:
Guardian Chemical & Equipment Co., Ltd.

Send new METASOL slimicide brochure detailing cost and production savings established by actual mill records.

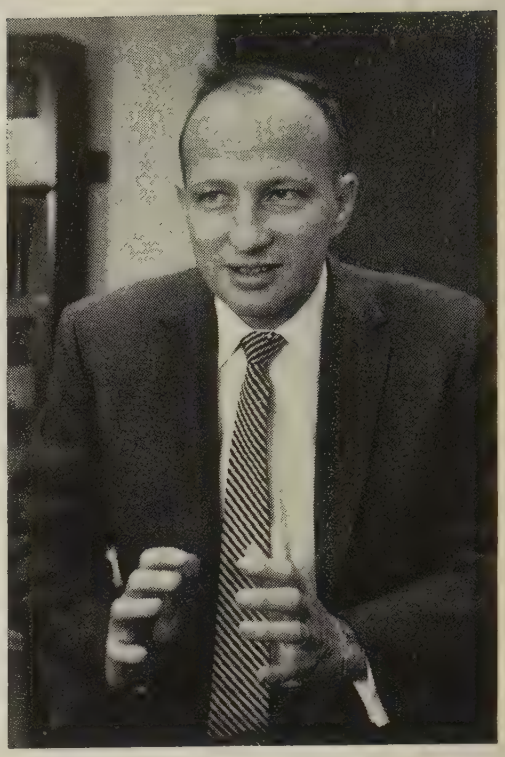
NAME_____ TITLE_____

COMPANY_____

ADDRESS_____ CITY_____ ZONE____ STATE_____

One in a series of interviews with the men who are "Virginia"

"Bleaching groundwood pulp with hydrosulfites can be done easily—with minimum capital investment—for less than $6 per pulp ton, including chemicals and steam for heating"



Robert Barton, a "Virginia" technical representative

Simplicity of operation, low cost, high pulp brightness—these factors have attracted many groundwood pulp processors to the use of either sodium or zinc hydrosulfite as their principal bleach agent.

The advantages of hydrosulfite bleaching are discussed by Robert Barton, a technical representative of Virginia Smelting Company.

Q How does the cost of bleaching with hydrosulfite compare with the cost of oxidizing bleaches?

A Extremely well. The cost of using zinc or sodium hydro usually runs less than one-half that of the oxidizing bleaches, and with equally good results.

Q Just what is the brightness gain using hydro?

A That question has to be qualified somewhat, I think. You see there are factors that have to be considered in bleaching groundwood pulp with hydro --the *p*H of the stock, temperature, reaction time, iron content of the pulp and of the process water. But with reasonably good conditions, single-stage bleaching with hydro will result in about 10 or 12 brightness points gained.

Q Does installation of equipment present any problem?

A Not at all. Most manufacturers who have gone to the hydro bleaching process are well pleased with the simplicity of the installation. And at the low cost, I might add. Generally they can use existing chests and pumps in their plants —adding necessary piping. Not much more is needed.

Q Do the hydrosulfites offer any advantages to a manufacturer now using peroxide for his bleach?

A Very definitely. In our laboratories at "Virginia" we have helped develop the 2-stage bleach for groundwood pulp that gives an absolute maximum brightness—at a cost that cannot be touched by any other method.

Q How does this 2-stage bleaching work?

A Well, for brightness gains up to 12 points, of course, the single-stage hydrosulfite bleach is the most economical. But for gains from 12 to 20 points, we recommend a 2-stage bleach. The first stage is a peroxide bleach. We follow that with a sulfur dioxide treatment to remove any residual peroxide in the slurry. This is followed by a hydro bleach. We will be happy to furnish all the data to anyone interested in this process.

Q Does "Virginia" offer technical assistance to any manufacturer interested in either the single-stage or 2-stage bleach process?

A A great deal. Our experience in this field is long and extensive, and available to anyone interested. For preliminary bleaching studies, we maintain a complete pulp laboratory at our plant. To solve certain types of problems, we obtain pulp samples, make laboratory bleaches, study the brightness gains along with any contributory factors, and make a complete report to the manufacturer. Along with the report go our recommendations—and of course our laboratory men are quite impartial in their findings. If the manufacturer has a process involving problems that make hydro impractical for any reason, we will tell him so quite frankly. But this occurs very infrequently. We welcome inquiries from any manufacturer interested in exploring the possibilities of hydrosulfites in pulp bleaching.

• • •

FOR MORE DATA ON HYDROSULFITES

write to us on your company letterhead describing your present bleaching process, giving full details wherever necessary. We will send you pertinent technical bulletins from the extensive "Virginia" library of literature on pulp bleaching. If you prefer, we will have a "Virginia" man call on you.

Industrial Division
VIRGINIA SMELTING COMPANY
Dept. 315 West Norfolk, Va.

VIRGINIA® Chemicals

Field Offices: New York • Boston • Detroit • Chicago • Atlanta • Asheville • Philadelphia • Akron • Seattle

Available in Canada and many other countries

YOU ASKED FOR IT...AND HUYCK HAS IT!

HUY-5

THE FIRST AND ONLY ALL-PURPOSE NATURAL COLOR CHEMICAL TREATMENT FOR MAKERS OF HIGH BRIGHTNESS BOARD AND MARKET PULP

HUY-5 gives felts outstanding resistance to . . .

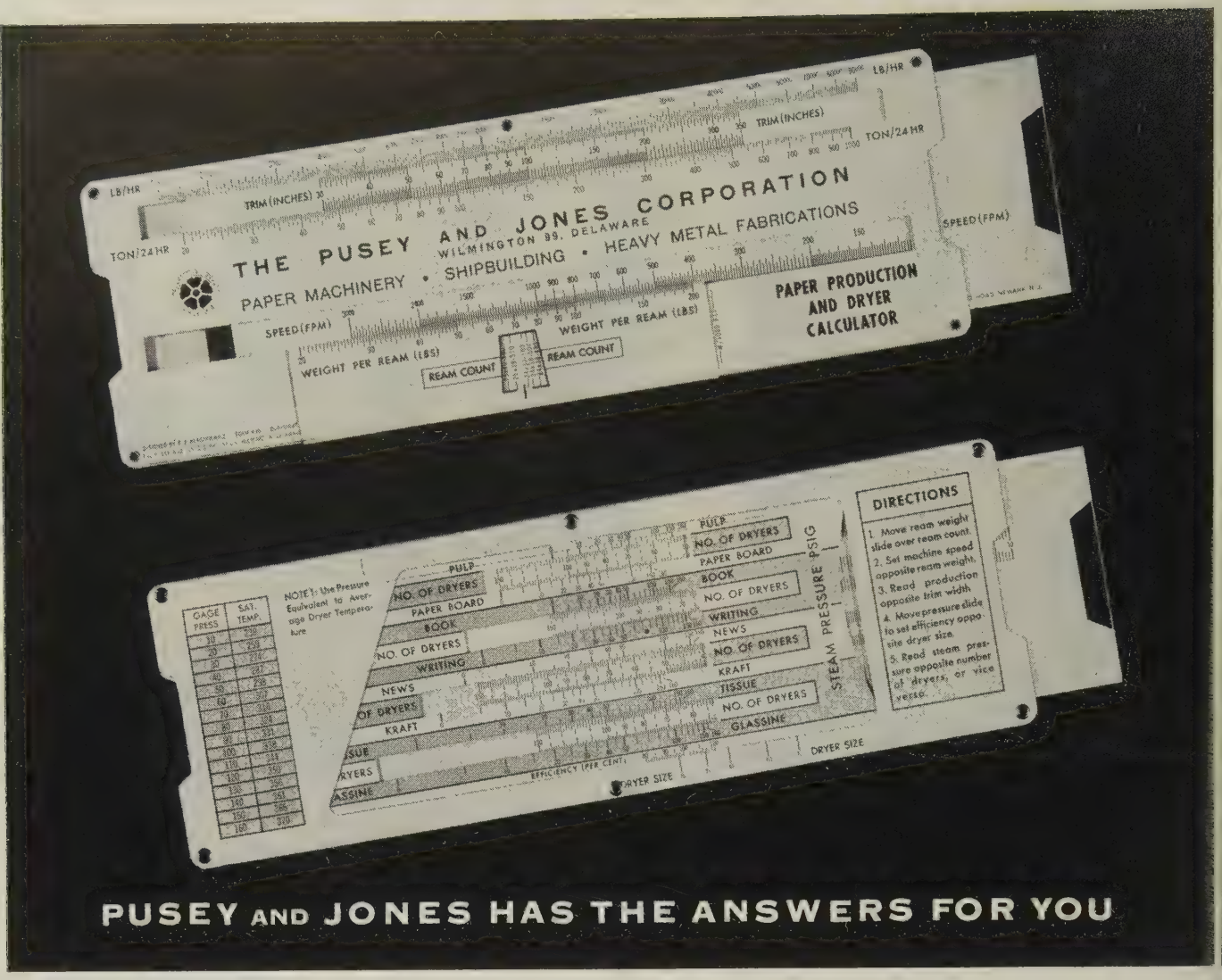
- **wear**
- **bacterial and chemical attack**
- **shrinkage or felting**
- **changes in running size**
- **hair shedding**

For the full story of the ways HUY-5 contributes to increase production . . . improve product quality and lower felt cost, talk to the Huyck Sales or Field Service Engineer who visits your mill.

Huyck Felt Co.,
Rensselaer, N. Y.,
Atlceville, Ala.,
Division of F. C. Huyck & Sons.
In Canada: Kenwood Mills Ltd.,
Arnprior, Ontario.

NEW HUYCK FELTS ☆ INDUSTRIAL FABRICS

FIRST IN QUALITY • FIRST IN SERVICE SINCE 1870



PUSEY AND JONES HAS THE ANSWERS FOR YOU

With Pusey and Jones' new free Calculator you can do a fast, accurate job of figuring ream counts, dryer size, type of paper and other mill data.

Just fill out the coupon—it will bring you Pusey and Jones' new Paper Production and Dryer Calculator—a new kind of slide rule that will save you many hours in your day-by-day mill operations.

It's easy to use, sturdily constructed and convenient—measures only 9½ inches by 3⅛! Not for sale anywhere, it's available *only* from the first company in the United States to specialize in the design and manufacture of paper-making machines. See a Pusey and Jones representative or write direct.

What you can do* with PUSEY AND JONES' NEW PAPER PRODUCTION AND DRYER CALCULATOR:

Figure This:	When You Know:
Daily and hourly production	Ream weight and count, speed and trim
Equivalent ream weight	Both ream counts
Speed	Desired production, any ream weight-count combination and trim
Number of dryers needed in a new machine	Weight, ream count, speed, type of paper and steam pressure
Dryer efficiency in your present machine	
Extra dryers or increased steam pressure required in rebuilding for greater production, change of speed, different weight or conversion to another type of paper	

**At least 8 different calculations can be made quickly and easily. Above calculations may be reversed or altered depending on knowns and unknowns.*

Please send one of your new Paper Production and Dryer Calculators.

NAME _____

POSITION _____

COMPANY _____

STREET ADDRESS _____

CITY _____ *ZONE* _____

STATE _____

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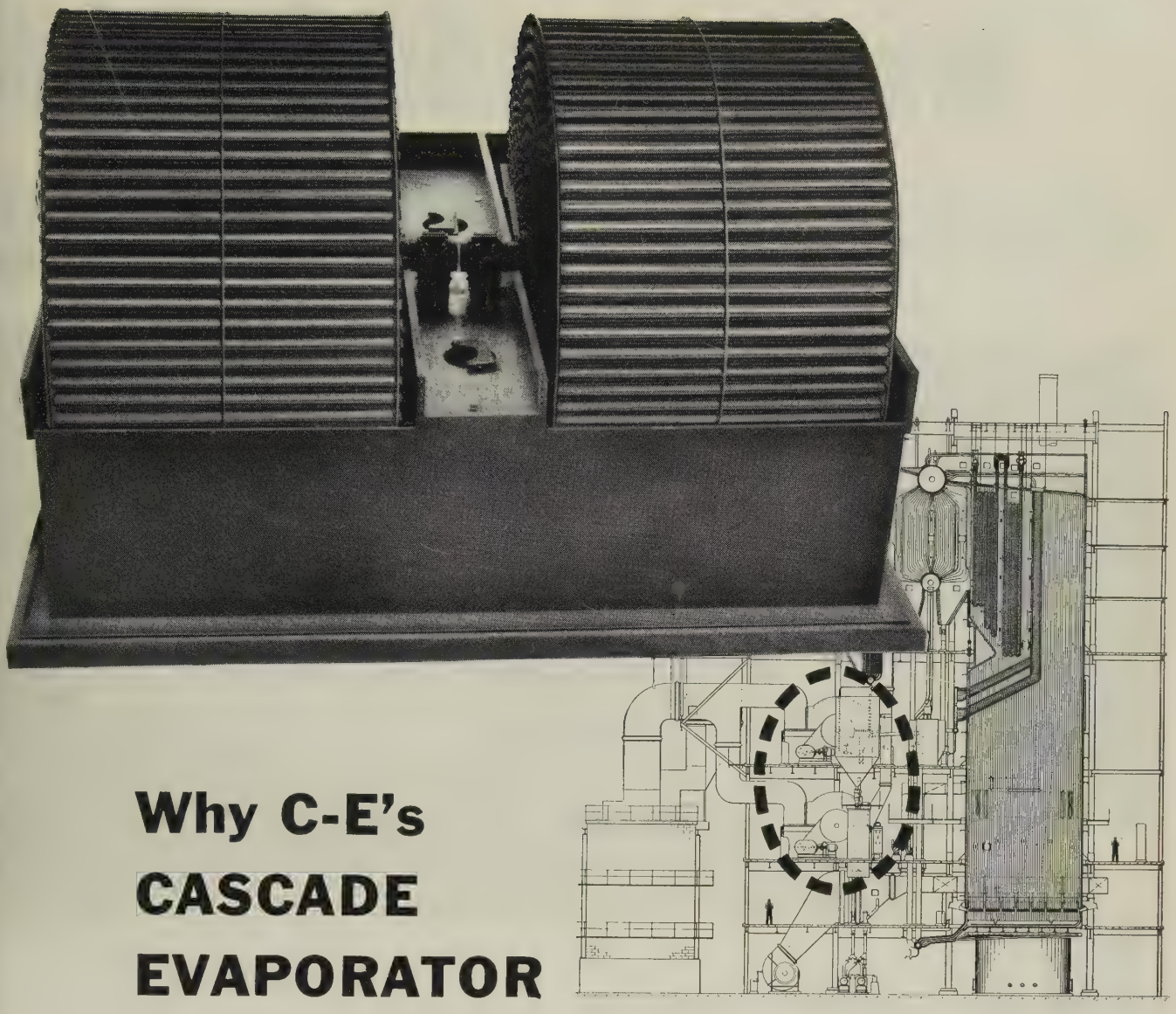

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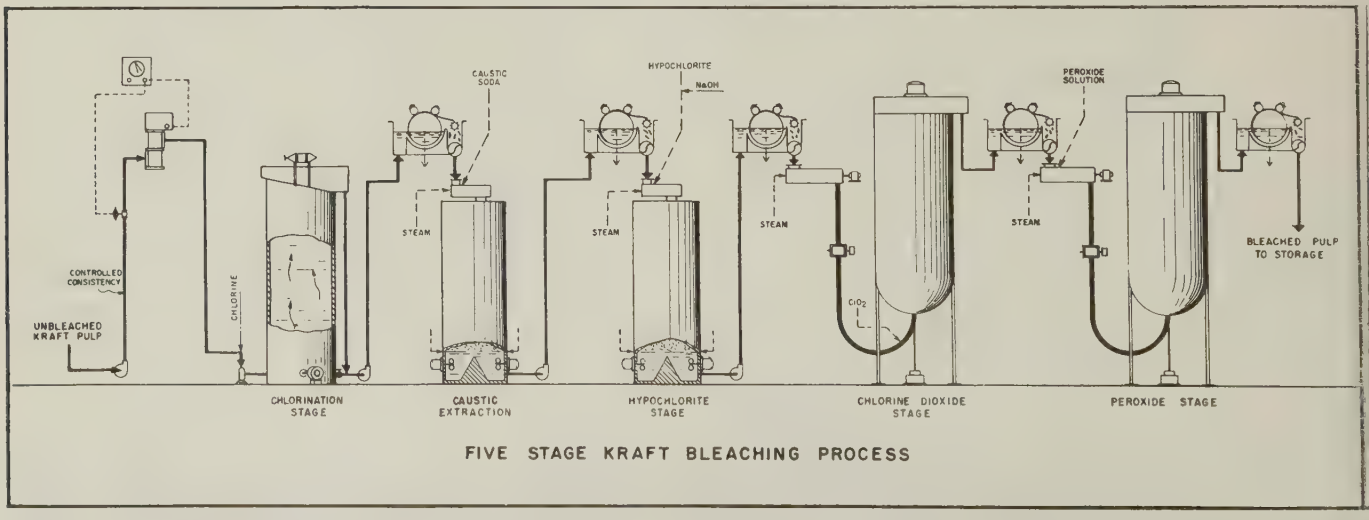

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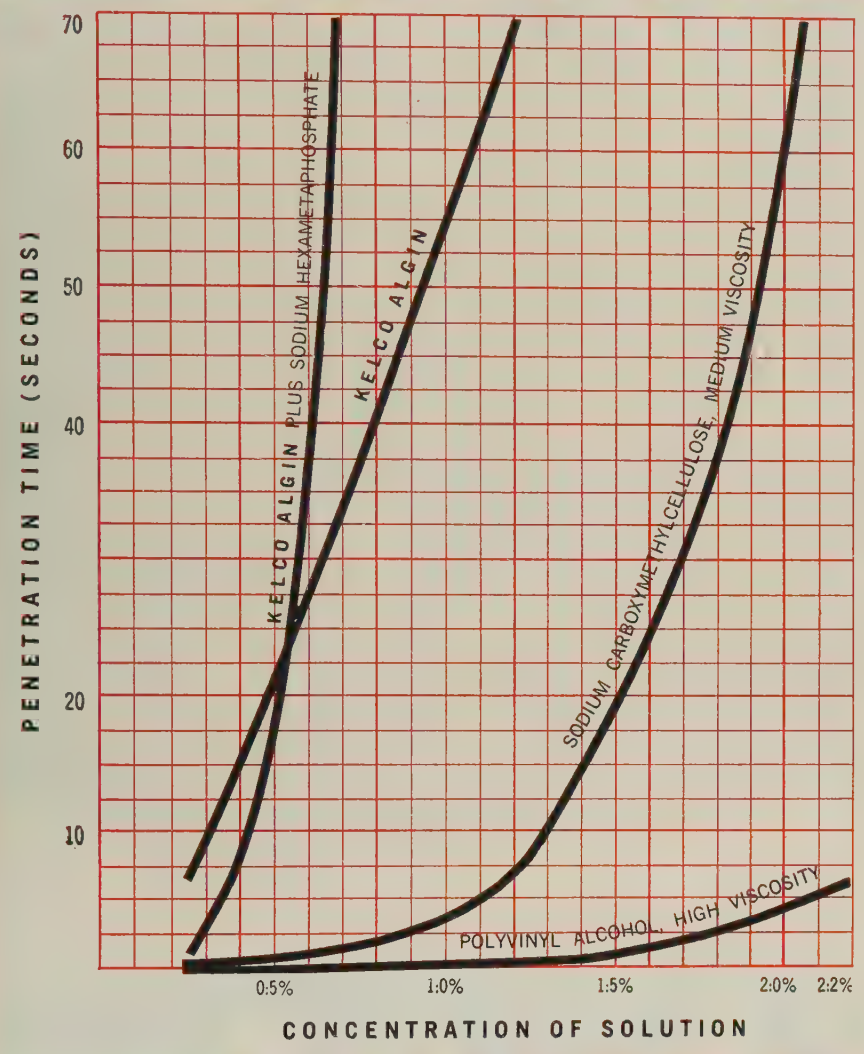

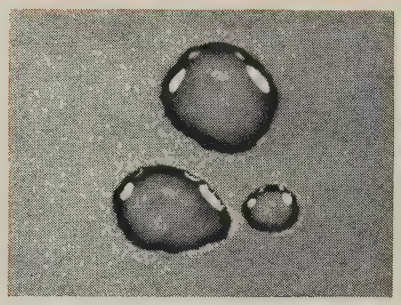

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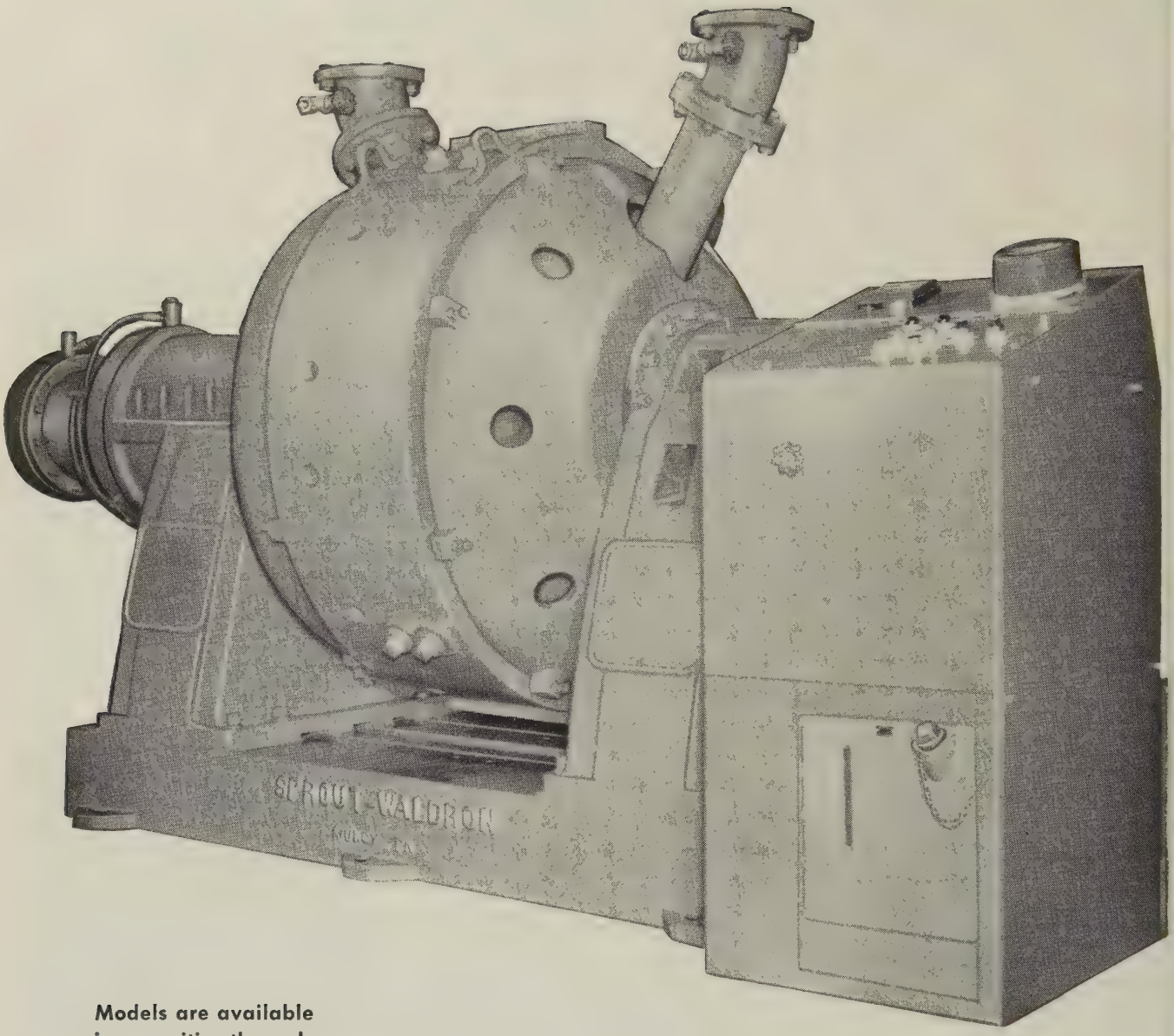

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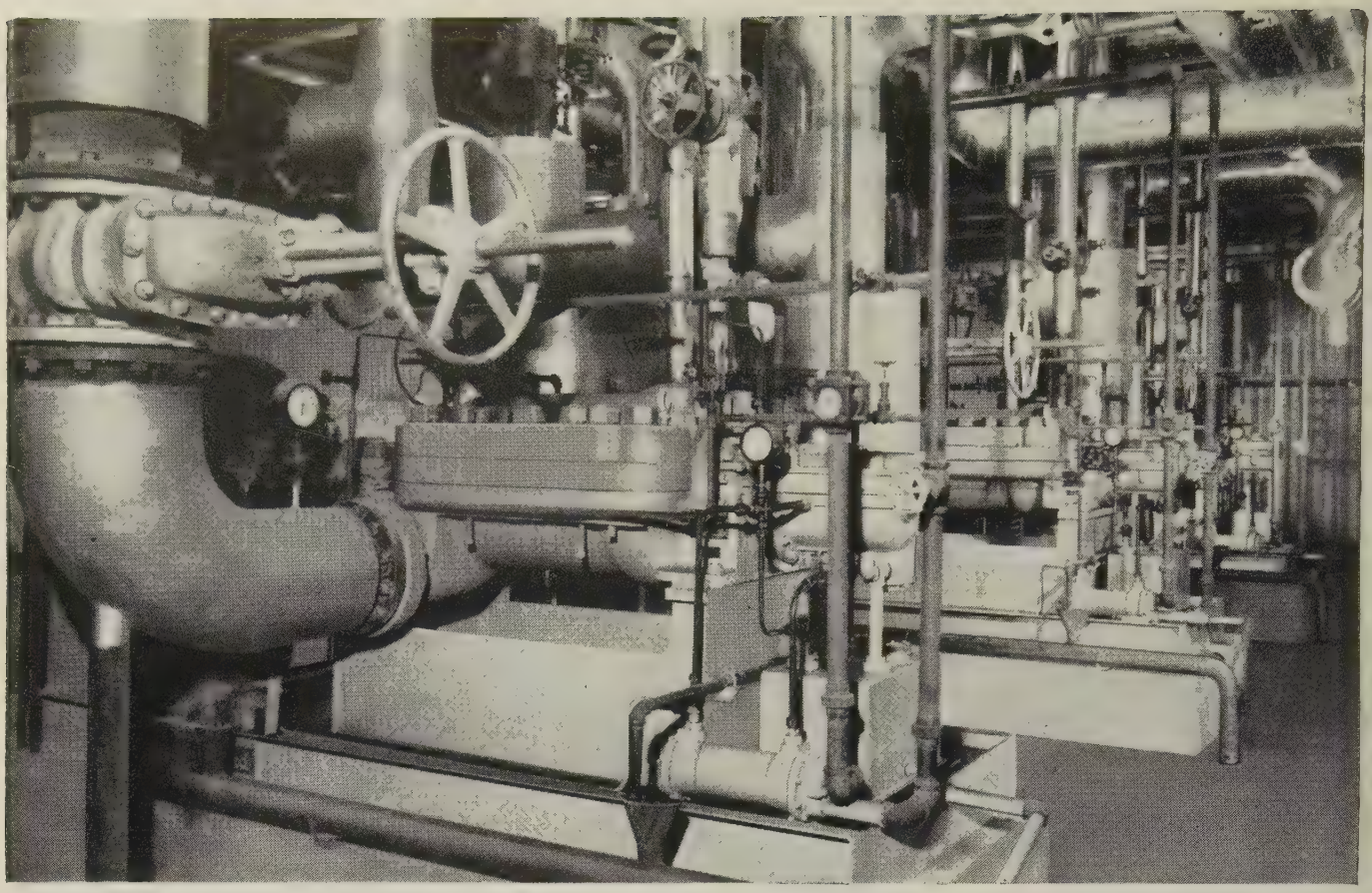

ST. REGIS PAPER COMPANY INSTALLS

3 MORE Ingersoll-Rand Boiler-Feed Pumps

FOR JACKSONVILLE PLANT EXPANSION

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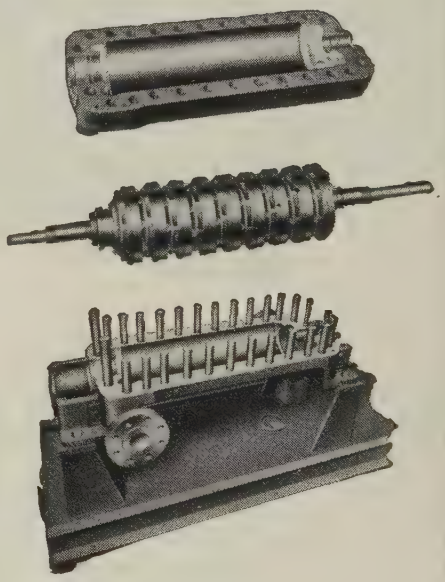

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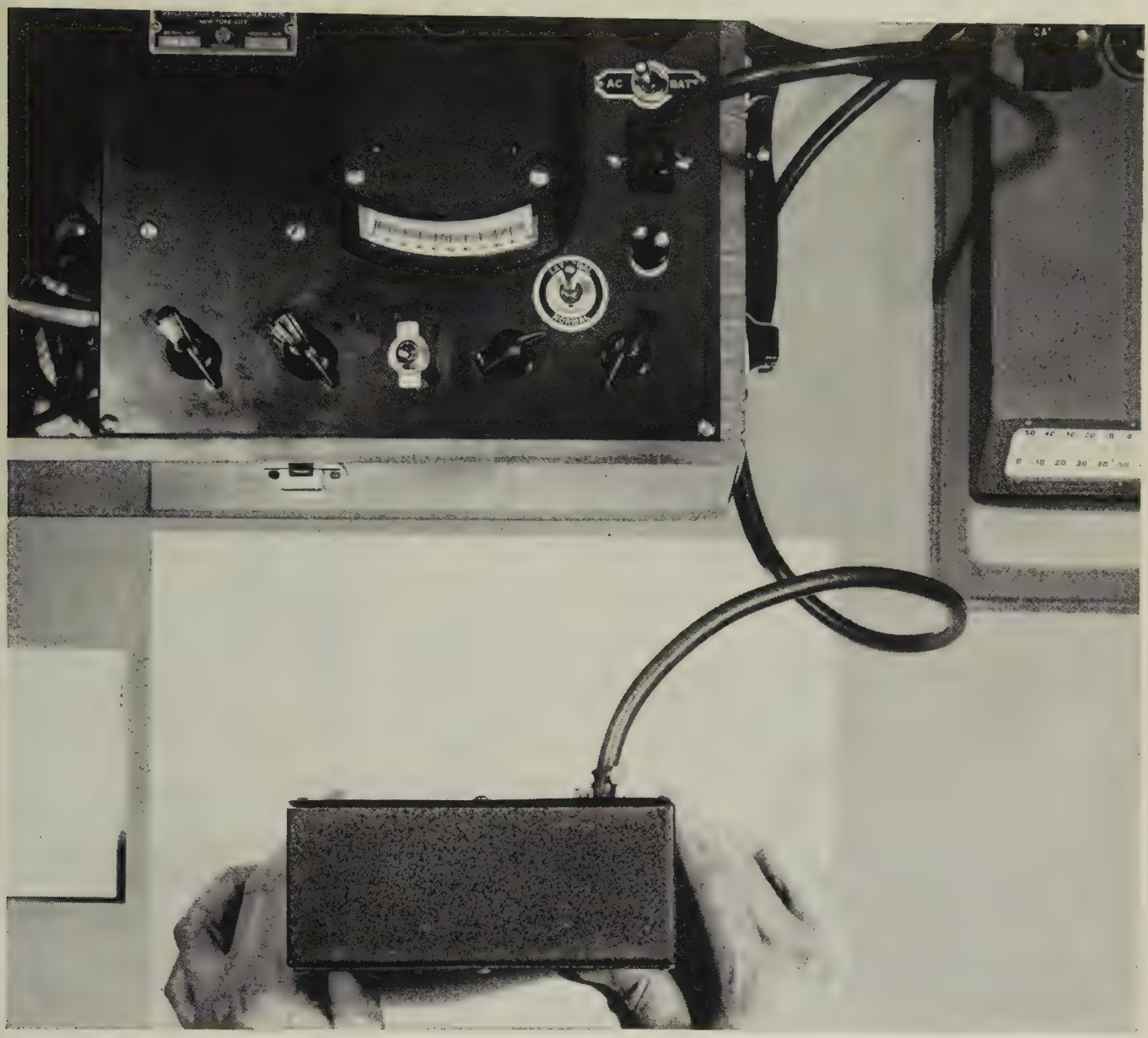

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Former coating	16	13	47%

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KRAFT, MAGNESIUM BI-SULFITE and NEUTRAL SULFITE

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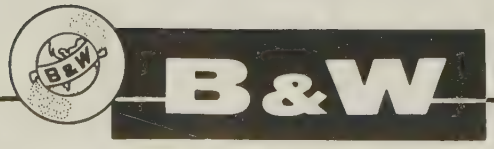

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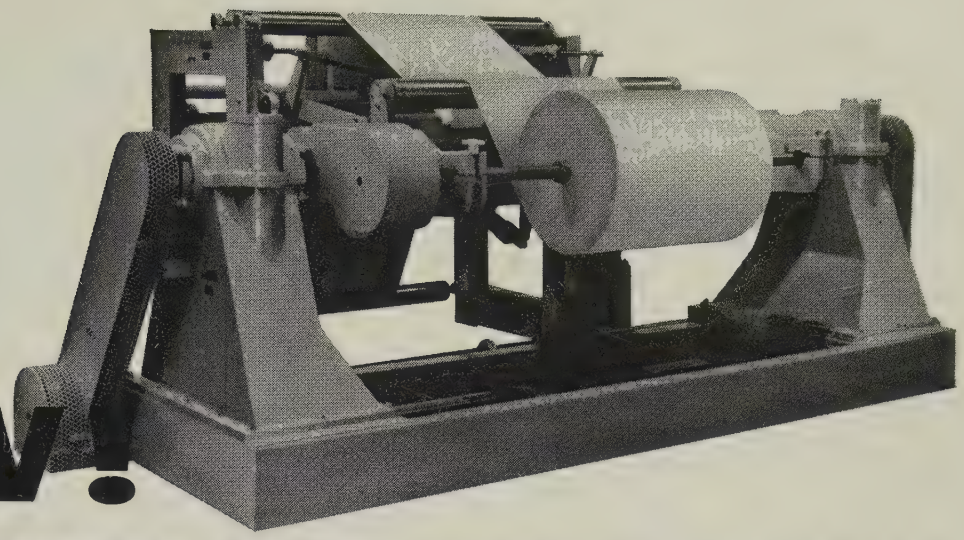

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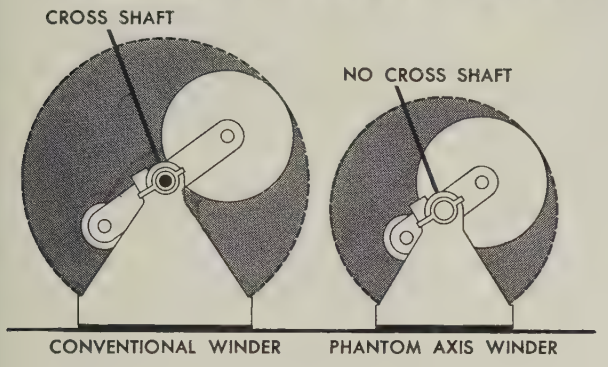

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Elimination of Malodors in a Kraft Pulp Mill

K. G. TROBECK, WALTER LENZ, and A. TIRADO A.

Experiences in the kraft pulp mill of Loreto and Peña Pobre indicate that only three sources of malodor will remain if the black liquor is properly oxidized. These three sources are: gases produced by the digesters, condensates also produced by the digesters, and gases delivered by the stack of the recovery boiler. An installation for the elimination of odors from gases and condensates from digesters, and one similar installation for handling gases going to the stack of the recovery boiler, have been successfully operated in Loreto and Peña Pobre for about 1 year. Use is made of the reaction between chlorine and gaseous sulphur compounds; however, a preliminary treatment of the sulphur compounds with air in presence of water produces a definite saving of chlorine as well as some additional benefits. Results of tests made to improve and clarify the different stages of the odor elimination system—including black liquor oxidation—are discussed in the paper.

ACCORDING to the extensive literature published on the subject, most of the processes intended for malodor elimination in kraft mills make use of either oxidation of black liquor with air or chlorination of gases or both. So, black liquor oxidation is described by Collins (*1*), DeHaas (*2*), Sylwan (*3*), Tomlinson and Ferguson (*4*), Trobeck (*5*), Wright (*6*), Wright and Klinck (*7*), Wright, Schoening, and Shemilt (*8*); and chlorination of gases is mentioned by Tomlinson and Ferguson (*4*) and Gordon and Creitz (*9*), among others.

BLACK LIQUOR OXIDATION

The oxidation of black liquor by means of air is a cheap procedure that prevents odors as long as it fixes sulphur compounds in the liquor, its good effect being reflected on all the places where oxidized black liquor is processed in the mill; but, of course, black liquor oxidation does not have any effect on odors produced in the digester room.

Results obtained in the kraft pulp mill of Loreto and Peña Pobre, in Mexico City, indicate that no bad smelling gases or condensates are produced in the evaporator and the recovery rooms provided that the oxidation of the sodium sulphide contained in the black liquor, runs higher than 90%, which means that the residual sodium sulphide should be lower than 1 g.p.l. This is true in spite of the fact that the condensing water from the barometric condenser of the evaporator is circulated through a water cooling pond in order to save fresh water. The water in the cooling pond is drained every week end, and therefore, this water has a good opportunity to become saturated with noncondensable gases; nevertheless, it has no odor provided that the pH remains on the alkaline side.

In addition, if the oxidation of black liquor is high enough to keep the residual sodium sulphide at a figure lower than about 0.2 g.p.l., the gases going to the stack of the recovery boiler will not contain obnoxious sulphur compounds. However, in order to accomplish this good result, sufficient excess air has to be used in the recovery boiler so that the combustion gases will contain at least 2% free oxygen; otherwise, some sulphur compounds can be chemically reduced to render again mercaptans, organic sulphides, etc., while the gases go to the stack. If the recovery boiler is overloaded, it will be difficult to maintain the required amount of free oxygen in the gases, thus making it necessary to have a special treatment for these gases before they go into the atmosphere.

Table I shows concentration of sulphur compounds in samples from different sources, as determined in Loreto and Peña Pobre by means of a Titrilog.

As described by Landsberg and Escher (*10*), the Titrilog is a chemical-electronic instrument which continuously records concentration of oxidizable sulphur compounds. The measurement is accomplished by a titration with bromine. The bromine is electrolytically generated in a solution in which the suphur compounds are absorbed. A feed-back amplyfying system controls the bromine generating current so that the net rate of bromine generation is at all times equivalent to the rate of absorption of the sulphur compounds. A recording milliameter records the generating current. The net current is proportional to the sulphur compound concentration in the sample.

It can be observed that the Titrilog measurements shown in Table I, still indicate small quantities of sulphur compounds to be present in the gases evolved from the evaporator condensate and the vents of the tanks even if no malodor can be detected by personal observation of the samples or walking around in the mill. Of course, this is due to the fact that a source of pollution should be measured not only by its concentration in obnoxious smelling compounds, but also by the rate of flow at which the total volume of gases goes into the atmosphere. Therefore, the allowable concentration of obnoxious compounds is higher as the flow of total gases decreases. So, due to the high flow rate of gases emitted by the stack of the recovery boiler, those gases constitute an important source of pollution even if its concentration in bad smelling sulphur compounds is rather low.

USE OF CHLORINATION OF GASES

Experiences carried out in Loreto and Peña Pobre indicate that the chlorination of gases, by itself, does not seem to be a suitable procedure to completely prevent bad odors from a kraft pulp mill. This is because of the practical impossibility of applying chlorine to each and every possible source of pollution, such as the vents of the tanks, or the places where obnoxious condensates and gases may be produced in the evaporator and recovery rooms when unoxidized black liquor is used.

K. G. TROBECK, President (deceased), Aktiebolaget B-T Metoder, Stockholm, Sweden; WALTER LENZ, Pulp Mill Director; and A. TIRADO A., Pulp Mill Superintendent, Fábricas de Papel Loreto y Peña Pobre, S.A., Villa Obregón, D.F. México.

Table I. Secondary Sources of Malodors

	Tritrilog, net reading.	*Sulphur compounds given as H_2S, p.p.m.*
Storage tanks		
(Concentration of sulphur compounds in gases coming out from different sources. Samples taken at 6 in. inside vent pipe)		
Vacuum tank of brown stock washers	40–55	2.44–3.55
Weak black liquor storage tank before oxidation	18–22	1.09–1.34
Weak black liquor storage tank after oxidation	11	0.67
Sealed tank. Barometric condenser of multiple effect evaporation	3	0.18
Condensate water from multiple-effect evaporator	2	0.12
Smelt dissolving tank	7	0.43
White liquor tank	11–15	0.67–0.92
Concentrated black liquor tank	22–28	1.34–1.70
Black liquor oxidation plant		
Vent from cyclone of oxidizing tower	17–23	1.04–1.40
Gases from recovery boiler		
(Black liquor was previously oxidized with an oxidation of 100%)		
Before scrubbing and chlorination	10–26	0.61–1.58
After scrubbing, chlorination, and final wash at pH of 6	8–20	0.49–1.22
After scrubbing, chlorination, and final wash at pH of 9	3–4	0.18–0.24
For comparison		
Gases from power boilers, burning fuel oil	2–3	0.12–0.18
Cigarette smoke. Cigarette at 2 in. from intake of sampling apparatus	90	5.49

On the other hand, the products from the chlorination of gases still contain odorous substances, as was quoted by Gordon and Creitz (*9*), or even they may contain harmful chemicals such as residual chlorine. Therefore, the chlorinated gases must be treated further to remove any obnoxious compounds.

In addition, the complete deodorization of a kraft pulp mill by means of only chlorine, would require large quantities of chlorine as Gordon and Creitz (*9*) pointed out. Those authors indicate that approximately 25 lb. of chlorine per ton of pulp is needed to eliminate the odor, so that the procedure would be so expensive to make the operation uneconomical in most places.

However, the reaction between chlorine and bad smelling sulphur compounds proceeds so rapidly and completely as to constitute a very important stage in the elimination of odors.

REACTION BETWEEN SULPHUR COMPOUNDS, AIR, AND WATER

Several years ago, K. G. Trobeck found that the quantity of mercaptans in condensate waters from kraft digesters, decreases as long as those waters are in contact with air in a sealed flask. At the same time, hydrogen sulphide is produced. He also found that the original mercaptan content of the condensate water was not affected, if the air was substituted by nitrogen. It seems that mercaptans can be converted into hydrogen sulphide by treating them with air and water. It is believed that the following reactions apply:

$$CH_3—SH + H_2O = CH_3OH + H_2S \quad (1)$$

$$2\,H_2S + O_2 = 2\,H_2O + 2\,S \quad (2)$$

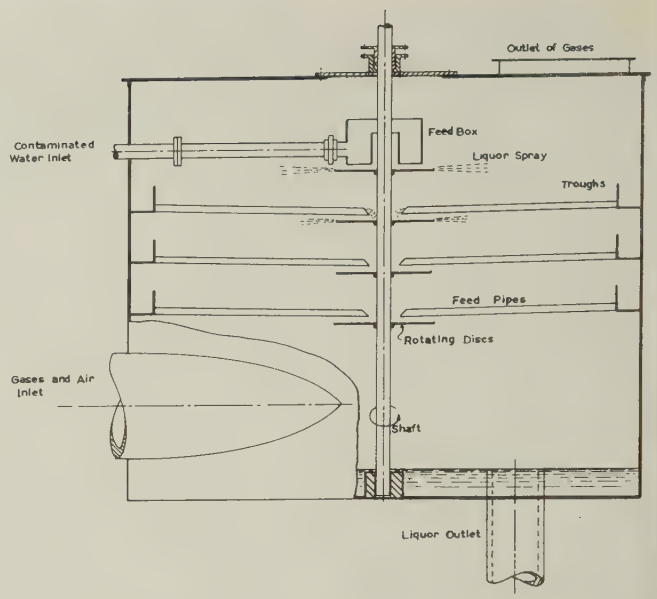

Fig. 1. Reactor being used to treat gases and contaminated condensate water by air

Reaction (1) proceeds up to a certain equilibrium depending on the temperature; nevertheless, it will go farther as long as the hydrogen sulphide is oxidized by the air according to reaction (2).

Having these reactions in mind, a reactor, as shown on Fig. 1, was built in the Loreto and Peña Pobre mill. This reactor promotes a good contact between air, noncondensable gases, and contaminated condensate waters, so that all the bad smelling compounds produced during the blow off and gas relieving of the digesters, are treated in one single apparatus. A definite reduction of the malodor from the gases and a still better elimination of the odor from the condensate water, were obtained as soon as the reactor was put in service. However, some hydrogen sulphide and small quantities of other organic sulphur compounds were still present in the gases at the outlet of the reactor, so that those gases were subsequently treated with a small quantity of chlorine to destroy its odor.

ODOR ELIMINATION IN LORETO AND PEÑA POBRE

A complete system for the removal of malodors from gases and condensates has been in successful operation in Loreto and Peña Pobre for about one year. The method, named TLT system, has proved that the bad odors can be economically and completely eliminated by means of a combination of the three basic processes already discussed:

1. Oxidation of black liquor.
2. Reaction between sulphur compounds, air, and water.
3. Chlorination of gases, followed by final scrubbing of the products of the reaction.

As a matter of fact, only three sources of malodors remain after the black liquor is oxidized, provided that the efficiency of the oxidation is sufficiently high. Those three sources are: gases and condensates produced by the digesters, and gases from the stack of the recovery boiler. Therefore, two installations, in addition to the black liquor oxidation system, were built in this mill: one installation to perform the treatment of gases and condensates produced by the digesters, and the other one to eliminate obnoxious compounds in

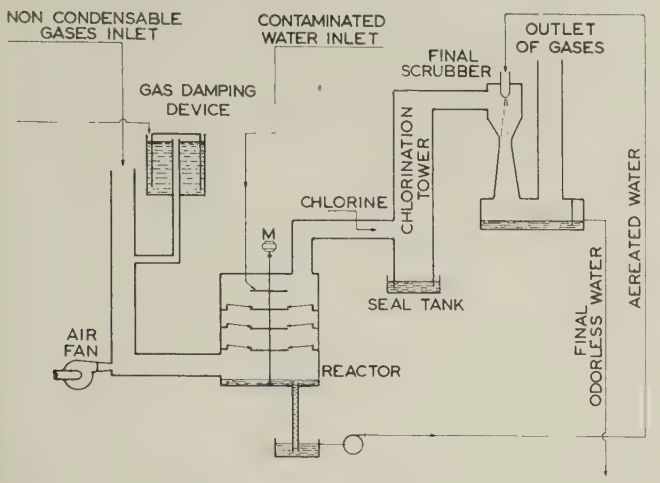

Fig. 2. Elimination of odors in gases and contaminated waters produced by the digesters

gases from the recovery boiler, as shown on Figs. 2 and 3, respectively. These installations are similar, as long as they operate under the same principles. Figure 3 is a diagram to show the stages needed to prevent odors from the stack of the recovery boiler.

Experimental results obtained in glass models, and also in commercial scale, are presented in the rest of this paper.

PERFORMANCE OF BLACK LIQUOR OXIDATION TOWER

In Loreto and Pena Pobre, the black liquor oxidation is accomplished by the system developed by Aktiebolaget B-T Metoder, which has been described in detail by Trobeck (*5*).

Briefly, such system consists of a tower having seven perforated plates or trays on which the contact between air and liquor is made. Liquor and air flow are countercurrent. The foamy liquor discharges from the oxidation tower into a foam (and liquor) storage tank. As shown below, this "foam tank" plays a very important role in the oxidation process.

Tests were conducted to determine pressure drops of air through the oxidation tower under variable air and liquor ratios.

Figure 4 shows pressure drops when the liquor consisted of plain water.

Figures 5, 6, and 7 indicate pressure drops when black liquor was used, each figure representing a different degree in the cleanliness of the tower. This is due to the fact the tower shows a certain tendency to collect solids—especially soap—that interfere with good oxidation. Figure 4 gives results obtained when the tower was "clean," such "clean" condition being reached at the end of a wash. This wash is accomplished by running hot water through the tower for about half an hour.

Figure 7 presents data obtained when the performance of the tower was very poor on account of the undesirable accumulation of solids that resulted after several weeks' continued operation without any wash.

Figure 6 gives pressure drops obtained after 1 week's continued operation. Data plotted on Fig. 6 are considered to correspond closely to the maximum allowable pressure drops, as long as higher losses will indicate that the accumulation of solids is high enough to reduce the efficiency of the tower. Figure 6 is used to determine the time in which the accumulated solids should be washed out.

Table II. Performance of the Oxidation Tower Itself on the Oxidation of Black Liquor. Air to Liquor Flow Ratio = 100:1

C_o Na_2S at inlet of tower, g.p.l.	C_i Na_2S at outlet of tower, g.p.l.	V Flow of liquor per sq. m. tower, cu. m./hr. × sq. m.	C_i/C_o Residual Na_2S, experimental, %	C_i/C_o Residual Na_2S, calculated, %
5.89	2.10	10.05	35.65	35.72
5.35	1.86	8.94	34.77	33.28
4.05	1.60	8.94	39.51	33.28
5.96	1.64	9.50	27.52	34.49
4.65	1.78	8.38	38.27	32.11
4.18	1.23	8.38	29.42	32.11
5.08	1.60	8.38	31.50	32.11
6.73	2.80	9.50	41.60	34.49
3.90	1.50	8.38	38.46	32.11
5.02	1.42	8.38	28.29	32.11
4.60	1.39	5.59	30.21	26.88
3.55	0.94	8.38	26.48	32.11
6.12	1.94	9.50	31.70	34.49
6.59	2.33	7.82	35.36	31.00
5.26	1.56	6.71	29.66	28.86
4.83	1.62	7.26	33.59	29.90
7.96	2.35	7.26	29.52	29.90
5.08	1.65	9.50	32.48	34.49
5.70	2.06	10.05	36.14	35.72
9.65	2.03	6.15	21.04	27.86

Dot-lines drawn on Figs. 5, 6, and 7 correspond to the usual 100:1 air to liquor flow ratio. This flow ratio has proved to bring about a good oxidation consistently, and has been adopted as a standard ratio. Therefore, all data pertaining to the efficiency of the oxidation process, as presented below, will refer to such 100:1 air to liquor flow ratio.

Table II presents data related to the performance of the tower. Concentrations of sodium sulphide in black liquor were determined by titration with $N/10$ $AgNO_3$ solution up to pH = 1.0. The pH was measured by means of a potentiometer having one conventional glass electrode and one silver billet metallic electrode

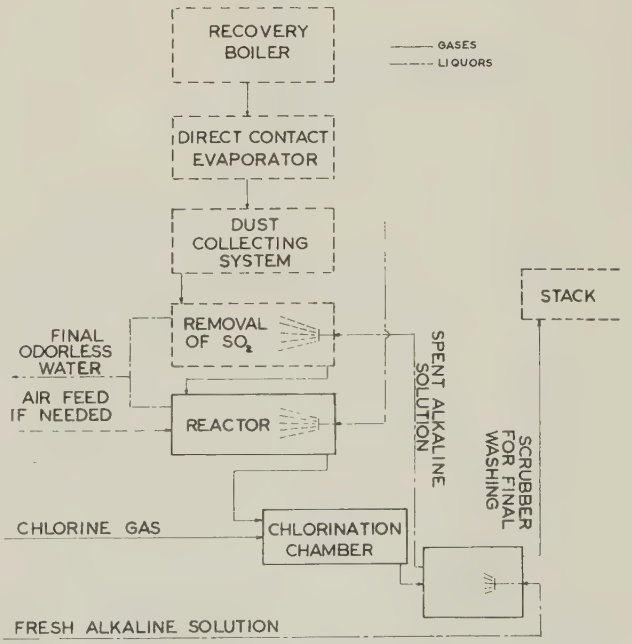

Fig. 3. Elimination of odors in gases going to the stack of the recovery boiler

coated with silver sulphide, as recommended by Borlew and Pascoe (*11*).

Table II indicates that not more than 60 to 80% of the sodium sulphide is oxidized in the tower. As shown in the fifth column on Table II, a fair correlation between the residual percentage of sodium sulphide and the amount of liquor flowing per square meter of tower, can be obtained by means of the equation

$$\log \frac{C_i}{C_o} = -0.7253 + 0.02768\, v$$

where

C_o = Na_2S in black liquor at inlet of tower, grams/liter.
C_i = Na_2S in black liquor at outlet of tower, grams/liter.
v = Flow of liquor per square meter of tower, cubic meters of liquor/hour × square meters.

By assuming that the sodium sulphide is oxidized on each tray in proportion to the existing sodium sulphide, the above equation is transformed to obtain:

$$\log \frac{C_i}{C_o} = -0.4343\, n\, (0.2386 - 0.0091\, v)$$

being n = number of trays in the tower.

A family of straight lines, representing this last equation, appears on Fig. 8, so that these lines give residual sodium sulphide (in percentage of the original value), that would be expected to result if towers of different number of trays were used. A vertical dot-line is traced on tray number seven, as this line indicates the end of the reaction being accomplished in the tower at Loreto and Peña Pobre.

Data shown in Table III are indicative of the unexpected results which are obtained due to the additional oxidation which takes place during the time that the liquor remains stored in the so-called "foam tank."

As mentioned by Sylwan (*3*), practically all the liquor is converted into foam in this type of tower, the foam producing an excellent contact between air

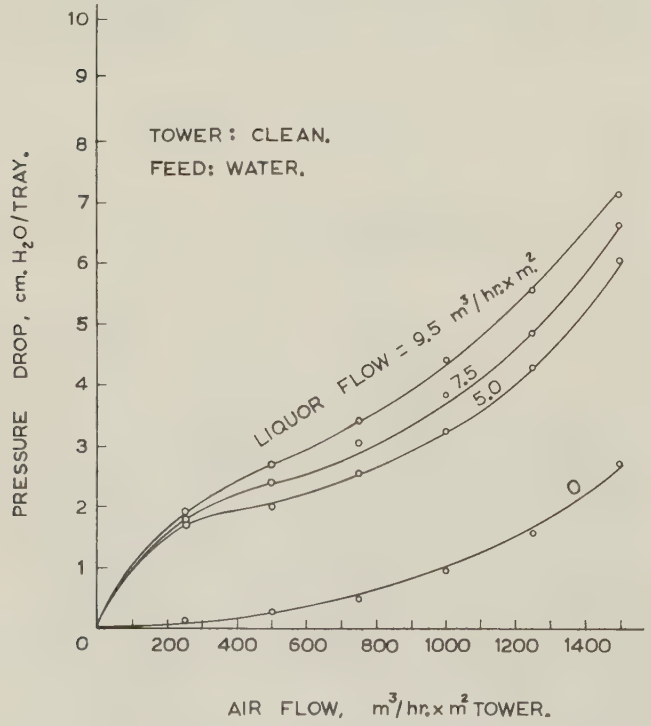

Fig. 4. Pressure drop through black liquor oxidation tower; the tower was running with water

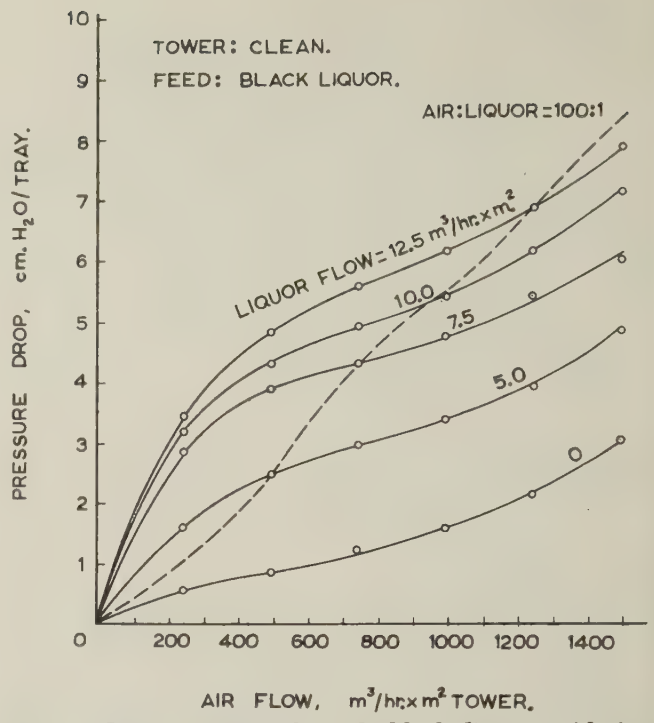

Fig. 5. Pressure drop through black liquor oxidation tower, as being measured after washing out all accumulated solids

and liquor in both the oxidation tower and the foam tank. However, a constant liquor level and no accumulation of soap should be allowed in the foam tank if part of the oxidation needs to be accomplished in that tank. Therefore, it is believed that an excess of air is dissolved in the liquor as it passed through the tower, and this dissolved air completes the reaction in the foam tank.

Values of average residual percentages of sodium sulphide at the outlet of the foam tank, are shown in Table III. To evaluate the part of the oxidation which is performed in the foam tank, such average values are also marked on Fig. 8, the marks being placed just on the lines that correspond to the given flow of liquor. Even if those averages are not very significant, it is estimated that the foam tank makes a job equivalent to 11 to 19 more plates, or 15 additional trays on the average. All these results refer to a foam tank having a ratio of diameter to height equal to 1, and 75 cu. m. total capacity per square meter of tower; notwithstanding, the liquor occupies only 50% of this volume.

EXPERIENCES WITH CHLORINATION OF GASES

To determine the chlorine consumption of gases produced by the digesters, samples of noncondensable gases—cooled down to about 30°C.—, were continuously introduced into a small glass reaction chamber where chlorine gas was added. Flows of gases and chlorine were measured by means of rotameters, and the addition of chlorine was adjusted so that the Titrilog net reading was zero. However, the Titrilog did not show a zero reading, unless a large quantity of free chlorine existed at the end of the reaction. No odorous mercaptans or hydrogen sulphide could be detected in the products at the end of the reaction, but those products consisted of a strong irritating mixture of acid gases.

This result is explained by the fact that the zero reading on the Titrilog is only an indication that gases capable of reacting with chlorine, and chlorine gas itself, are introduced through the Titrilog in equimolecular quantities; nevertheless, the reaction may be incomplete. This is because, as Landsberg and Escher (*10*) point out, the Titrilog gives a positive reading when sulphur compounds are tested, even if they consist of products such as sulphur dioxide. On the other hand, free chlorine should give a negative reading. Therefore, it will be impossible to have no free chlorine and read zero on the Titrilog at the same time, unless the sulphur compounds are oxidized farther than the sulphur dioxide level. Such condition would require an extreme oxidation that in our tests was neither reached nor desired.

Table III. Performance of the Oxidation Tower Plus the Foam Tank on the Oxidation of Black Liquor. Air to Liquor Flow Ratio = 100:1

C_o Na_2S at inlet of tower, g.p.l.	C_f Na_2S at outlet of foam tank, g.p.l.	v Flow of liquor per sq. m. tower, cu. m./hr. × sq. m.	C_f/C_o Residual Na_2S, %	C_f/C_o Average residual Na_2S at outlet of foam tank %
2.73	0.004	6.5	0.01	
2.28	0	6.5	0	1.18
4.94	0.234	6.5	4.70	
5.41	0	6.5	0	
1.68	0	5.5	0	
3.61	0.214	5.5	6.00	
3.34	0	5.5	0	1.20
4.55	0	5.5	0	
9.65	0	5.5	0	
1.97	0.062	6.0	2.70	
2.09	0.156	6.0	6.40	
2.21	0.031	6.0	3.10	2.03
2.34	0	6.0	0	
4.24	0	6.0	0	
5.54	0	6.0	0	
2.44	0.078	7.0	2.60	
2.86	0.117	7.0	4.42	
3.34	0.152	7.0	4.50	4.06
4.29	0.390	7.0	8.80	
4.68	0	7.0	0	
3.30	0.016	7.5	0.50	
4.08	0.020	7.5	2.40	
5.19	0.519	7.5	9.70	4.15
5.02	0.132	7.5	2.80	
5.42	0	7.5	0	
8.20	0.790	7.5	9.50	
3.51	0.203	8.0	6.10	
3.66	0	8.0	0	
4.49	0	8.0	0	4.62
5.57	0.470	8.0	8.20	
7.95	0.700	8.0	8.80	
3.59	0	8.5	0	
4.86	0.148	8.5	2.90	3.45
4.60	0.350	8.5	5.40	
4.95	0.272	8.5	5.50	
2.89	0	9.0	0	
4.00	0.250	9.0	4.80	
4.80	0	9.0	0	4.20
5.01	0.445	9.0	9.20	
6.40	0.435	9.0	7.00	
1.87	0	9.5	0	
3.16	0.039	9.5	1.30	
3.95	0.078	9.5	1.60	2.14
4.14	0	9.5	0	
4.96	0.390	9.5	7.80	
3.10	0.136	10.0	4.20	
3.94	0.058	10.0	1.00	3.47
4.31	0.018	10.0	0.50	
6.30	0.504	10.0	8.20	
6.01	0.350	11.0	6.00	3.0
1.80	0	11.0	0	

Several types of reactions may take place due to the action of chlorine on gases containing sulphur compounds, each reaction corresponding to a different degree of oxidation:

$$2\ CH_3{-}SH + Cl_2 = CH_3{-}S{-}S{-}CH_3 + 2\ HCl \quad (1)$$

$$CH_3{-}SH + 2\ Cl_2 + H_2O = CH_3{-}SO{-}Cl + 3\ HCl \quad (2)$$

$$CH_3{-}SH + 3\ Cl_2 + H_2O = CH_3{-}SO_2{-}Cl + 5\ HCl \quad (3)$$

$$H_2S + 3\ Cl_2 + H_2O = SO_2 + 6\ HCl \quad (4)$$

$$H_2S + 4\ Cl_2 + 3\ H_2O = SO_3 + 8\ HCl \quad (5)$$

However, it is expected that the products of reaction (1) still produce malodors, while the products of reactions (2), (3), (4), and (5), should not produce bad odors but irritating acid gases in an increasing degree. Relative chlorine consumption for each of the listed reactions should be:

(1): $\frac{1}{2}$ mol. Cl_2 per atom of sulphur = 12.5%
(2): 2 mol. Cl_2 per atom of sulphur = 50%
(3) and (4): 3 mol. Cl_2 per atom of sulphur = 75%
(5): 4 mol. Cl_2 per atom of sulphur = 100%

Therefore, it may be concluded that a large quantity of chlorine—as indicated by reaction (5)—will be consumed by the gases, if the products of the reaction show a zero reading on the Titrilog. Nevertheless, about 50% of this quantity of chlorine will destroy the odor. This conclusion was experimentally confirmed. No malodors could be detected when chlorine was added at only 50% of the total demand the Titrilog was indicating. Even at this reduced chlorine demand a small quantity of free chlorine existed at the outlet of the chlorination chamber in spite of the fact that the Titrilog showed a positive reading.

Therefore, new tests were made to determine the 50% chlorine demand of the gases. Because of the

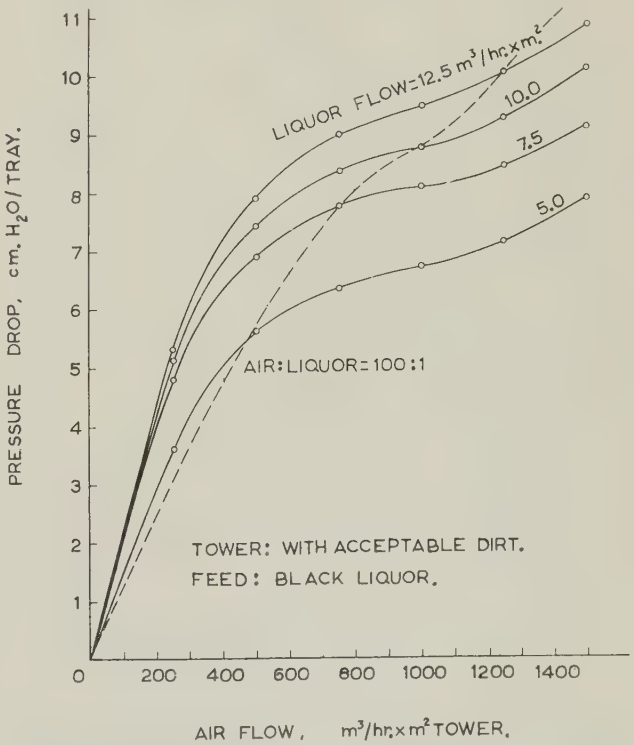

Fig. 6. Maximum allowable pressure drop through black liquor oxidation tower; this condition is normally obtained after one week operation

changeable nature of the gases being tested, the dosage of the chlorine gas presents some practical difficulties. However, it was possible to keep the reaction under control and record the maximum and minimum readings, as well as to get a weighted average, for periods of about 10 min. in which the chlorine demand of the gases appeared to remain approximately constant. Data shown in the first three columns on Table IV are indicative of the results obtained with gases delivered by the digesters at different stages of the cooking cycle. A weighted average for the total cycle indicates that about 300 g. Cl per cu. m. of gases should be added in order to destroy the odor.

EFFECT OF AIR AND WATER ON THE GASES

Tests were also conducted in order to determine if the addition of air, in presence of water, had any real effect on the gases produced by the digesters. Those tests were carried out by introducing mixtures of air and noncondensable gases—at about 30°C.—into a small glass packing tower, the products of this reaction being delivered to the same glass chlorination tower which was used in the tests mentioned above. At the same time, an excess of liquid water flowed countercurrent through the packing tower. Air to gas ratios from 0.4 up to 1.8 were tried out without noting any substantial change in the chlorine demand. Column nos. 4, 5, and 6 on Table IV show the results obtained from these tests, indicating that a saving of about 20% Cl will be attained if the gases are previously treated by air in presence of water.

Other tests were made by subjecting the products that resulted from the air and water treatment to a caustic wash in a final scrubber. These tests showed another reduction of the chlorine requirement, which amounts to about 67% of the expected value, or about 50% of the original chlorine demand of the gases. It is believed that some unoxidized sulphur compounds are removed by means of the caustic wash before the Titrilog takes the sample, and this results in a further chlorine saving. In any case, the products delivered to the atmosphere are virtually odorless after this final wash.

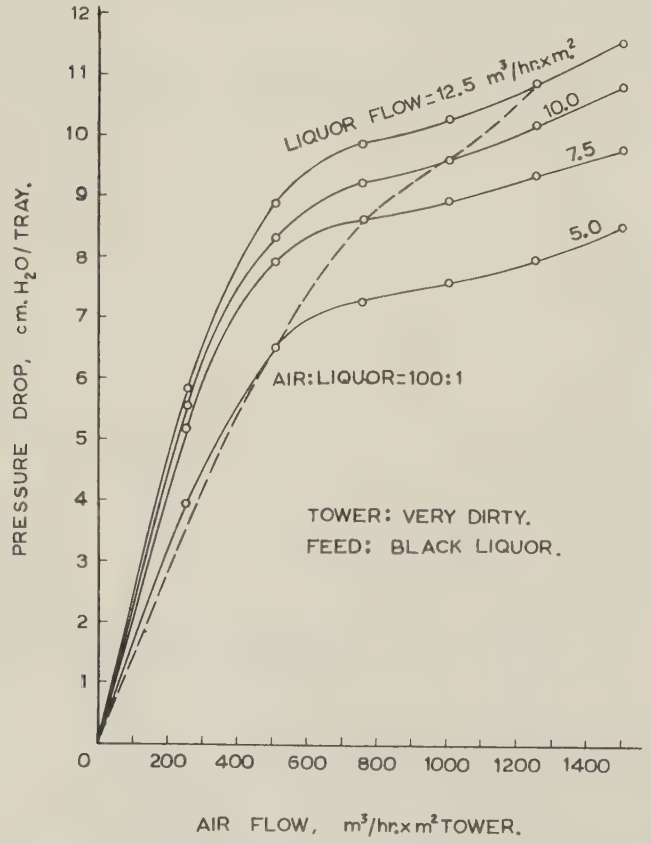

Fig. 7. Pressure drop through black liquor oxidation tower; an excessive amount of solids was accumulated because of several weeks continued operation without any wash

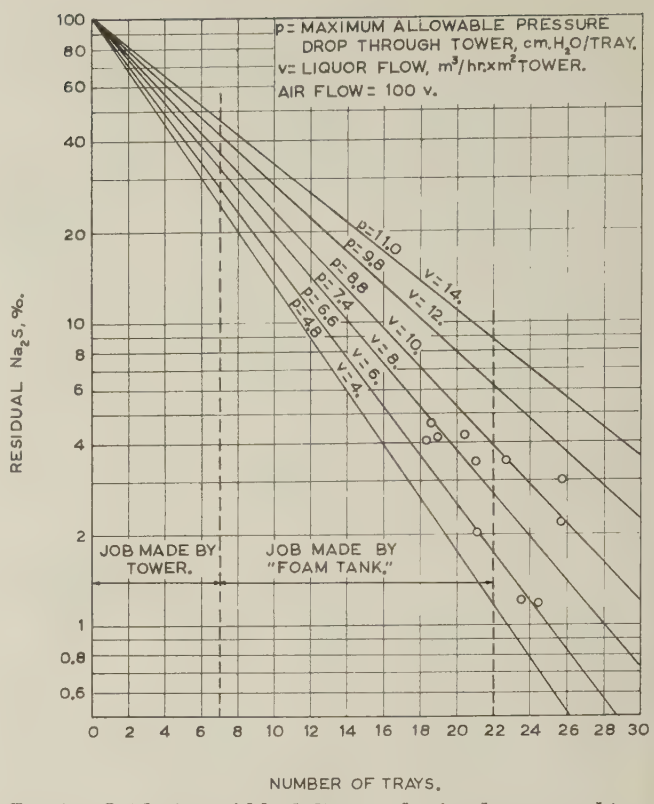

Fig. 8. Oxidation of black liquor obtained as a combination of the reaction performed in the oxidation tower and the "foam tank"

CONCLUSIONS

Results obtained in Loreto and Peña Pobre indicate that it is possible to virtually eliminate all the malodors commonly found in kraft pulp mills. Three separate installations are provided for this purpose in that mill, each installation performing one of the following operations:

1. Oxidation of black liquor by means of air.
2. Treatment of gases and contaminated condensates produced by digesters. This treatment consists of a preliminary reaction between air and sulphur compounds in presence of water—in this case, contaminated condensate water. Then, the gases are treated with chlorine, and the final products of this reaction are scrubbed in a caustic solution.
3. Treatment of gases going to the stack of the recovery boiler. A similar method, as the one applied to gases produced by the digesters, is used at this point.

A definite reduction in the chlorine demand of the gases is attained when the gases are subjected to a preliminary treatment with air and water in a reactor. However, this preliminary treatment appears to perform a specific job in the elimination of malodors, as deduced from the following facts:

1. In order to see experimentally if people could detect any change in the level of odor around the mill,

Table IV. Chlorine Requirement of Gases Produced by the Digesters with and without Additional Treatments

Chlorine consumption of gases without pretreatment, grams Cl_2/cu. m. gases — *Without final wash.* Av.	Max.	Min.	*Chlorine consumption of gases being pretreated by air in presence of water, grams Cl_2/cu. m. gases* — *Without final wash.* Av.	Max.	Min.	*With final caustic wash.* Av.	Max.	Min.
A. Gas Relieving Period. Normal Relieving Time = 120 min.								
244	260	220	184	270	130	...	...	...
200	200	200	165	190	140	...	...	...
153	200	100	98	130	70	...	...	...
422	540	340	243	320	130	...	...	...
Av. = 254.7 (100%)			Av. = 172.5 (68%)					
B. Pressure Relief. Relieving Time = 15 min.								
400	400	400	292	410	160	223	350	110
387	480	290	373	440	270	...	...	...
240	250	230	210	370	60	...	...	...
580	830	350	608	710	480	...	...	...
Av. = 401.7 (100%)			Av. = 370.7 (92%)					
C. Blow Off. Blowing Time = 18 min.								
525	660	400	515	640	360	443	490	410
400	520	200	440	440	440	157	310	50
Av. = 463 (100%)			Av. = 478 (103%)			Av. = 300 (65%)		
Weighted Averages for the Three Cooking Stages:								
120 min. × 255 = 30600			120 min. × 173 = 20760					
15 min. × 402 = 6030			15 min. × 371 = 5565					
18 min. × 463 = 8334			18 min. × 478 = 8604					
153		44964	153		34929			
Av. = 294 (100%)			Av. = 228 (78%)					
			15 min. × 292 = 4380			15 min. × 223 = 3345		
			18 min. × 478 = 8604			18 min. × 300 = 5400		
			33		12984	33		8745
			Av. = 393 (100%)			Av. = 265 (67%)		

the introduction of air, as well as the operation of the reactor was shut down for a couple of weeks, notwithstanding the chlorination of gases was normal. It was estimated that the level of odor increased by 30 to 50%.

2. A tendency towards the oxidation of sulphur compounds exists due to the air in the reactor, as indicated by comparing the amount of sulphides measured in the contaminated water at the entrance of the reactor with the one obtained at the outlet of said reactor. Such oxidation varies from zero to 100%; nevertheless, no correlation has been found to exist between the apparent variables of the process.

Though the role played by the air is not well established, it is presumed that mercaptans can react with water to produce hydrogen sulphide, plus alcohols, the hydrogen sulphide—and some other organic sulphur compounds—being partially oxidized by the air. Then chlorine is added, which seems to result in a more complete and economical reaction than the one performed if the preliminary air treatment were not used. In addition, a reduction in the intensity of malodors may be obtained due to the favorable threshold limit of hydrogen sulphide in comparison with the one of mercaptans. As a matter of fact, the odor control system in Loreto and Peña Pobre was started by erecting only the reactor. Of course, the results were not perfect, but a substantial quantity of bad odors was eliminated at once, without adding any chlorine.

Commercial operation of the whole system indicates that malodors can be eliminated very well, except for a few seconds during the blow. This is due to difficulties in making the present instrumentation operate properly. When the instruments fail, a big surge of steam goes into the apparatus and this steam cannot be handled properly as long as it reduces the actual retention time and makes it necessary to shut down the air to the apparatus. This should account for the rather poor results obtained during the blow, as indicated on Table IV. Manual dosage of the chlorine is another problem. However, new instruments will be installed in a near future, and then it is expected that a complete elimination of malodors will be virtually achieved.

In addition, a venturi-type fume scrubber—as shown at the upper end of the chlorine chamber shown on Fig. 2—will take the place of a small packing absorption tower which is used at present, so that the final wash will be better performed in the future. It is believed that no caustic solution will be required in this scrubber, since the free chlorine can be advantageously absorbed by the residual sulphur compounds contained in the contaminated water, as indicated on Fig. 2.

The amount of gases produced by the digesters makes a total of 7 to 12 cu. m. per ton of pulp in Loreto and Peña Pobre, so that, according to data appearing in Table IV, the chlorine requirement should vary from 1.5 to 3.0 kg. per ton of pulp. In practice, about 3 kg. Cl is used continuously. This high figure is due to the need of keeping a certain excess of chlorine at the end of the reaction, as long as the chlorine addition is manually controlled and subjected to human failures.

Gases from the recovery boiler require about 0.3 to 0.4 kg. Cl per ton of pulp.

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The Dispersion of Pigments for Coating Color: Concept and Theory

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An explanation is developed for the changes in consistency and flow properties which take place during the process of dispersing a pigment, for inclusion in a coating color. Dispersion is described in terms of deflocculation and disaggregation. After deflocculation or disaggregation, the particles of a pigment are able to pack together more closely, or, in effect, to take up less room in the suspension which constitutes the coating color. The progress of the dispersion can be followed by the change in volume which the pigment effectively occupies, namely, the relative sediment volume. The picture is emphasized that a coating color consists of a fluid phase, containing the adhesive, and a solid phase, which is the pigment. The principle of mechanical disaggregation is that a force must be applied to the aggregate which is sufficient to overcome the strength of the cemented areas, using the axis of the particle as the mechanical lever through which the force is applied. The conditions under which a machine can apply force to the pigment particles to bring about their separation in the dispersion process, are governed by the proportionality between the volume of fluid and the volume of voids between the pigment particles, the latter being directly related to the sediment volume. A diagram can be made, plotting the solids content of the suspension against the relative sediment volume of the pigment. The actual composition and consistency are then related to the calculated line which algebraically relates the two quantities of the graph for the case of a packed sediment. Using such a dispersion diagram the behavior of particles in a typical dispersion sequence can be explained, or, a dispersion sequence can be designed. The diagram is also useful in understanding the performance of different types of dispersion machines, particularly comparing kneader-type machines to higher-speed agitators.

The symptoms of the state of dispersion of pigments are seen at all stages of the processes of preparing coating color and of coating paper. While the pigments are being kneaded or mixed, the changing state of dispersion is manifested in the changing fluidity of the mixture. In the coating color, the viscosity of the color reflects, among other things, the state of the dispersion of the pigments in it. On the paper, the gloss, smoothness, and freedom from projecting particles reflect the dispersion of the pigments at the time the coating was laid on the paper. These characteristics are matters of common experience in the coating of paper, and it is well known that they correlate with the manner in which the pigment is treated, particularly with regard to the type of equipment in which it is mixed with water, dispersing agents, and the other ingredients of the coating color, and also with the solids content of the mixture while it is being mixed.

The purpose of this paper is to describe an underlying basis which is common to many dispersion processes. Emphasis is placed upon processes in which a dry, or nonfluid, pigment is put into a slurry.

BASIC CONCEPTS OF DISPERSION

The properties which a pigment may have, in addition to its chemical composition, are a particular arrangement and size of particles. The description of the particles may be simple or complex. In the case of particles which remain separate and unattached from each other, the properties which determine the behavior are particle shape, which may be describable as crystalline form and habit, and particle size distribution. This, however, is the exceptional case. Usually the particles will be stuck together, and there is no limit to the varieties of ways in which this may occur. Particles can be assembled in clusters, in which the particles are more or less tightly packed together, and in which there may be few or many individual particles. To the description of individual particles is added the number of particles in the cluster, the density of packing in the cluster, the arrangement of the particles in the cluster, surface smoothness of the cluster, the mobility or otherwise of the particles in the cluster, and the resistance to breaking or rearrangement of the cluster. The process of dispersion is considered to be the disruption of clusters of pigment particles.

The clusters may be held together by chemical deposits at the points of contact of the particles, to give them strength almost equal to that of single particles of the same size. On the other hand, the particles may be held together loosely, as though each were attracted by magnetic or gravitational forces, so that an applied force will disturb and break particular arrangements of the particles. The term disaggregation is applied to the disruption of clusters of particles which are held together by deposits at their points of contact, as by cement. Once the particles are broken apart, the bonds will not be reformed, and the process of disaggregation is therefore irreversible. The term deflocculation is applied to the disruption of particles which are held together more loosely, as though by magnets. When the bonds are broken by an applied force, they will be reformed again when the force is removed. The process of deflocculation is therefore reversible. The term disagglomeration is a generic one, and includes both deflocculation and disaggregation.

The problem of preventing the re-forming by floccu-

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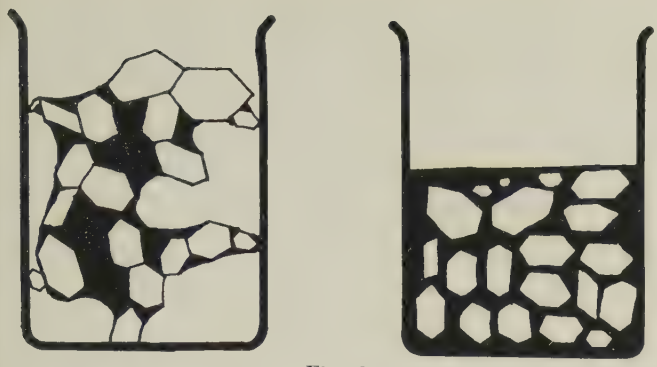

Fig. 1

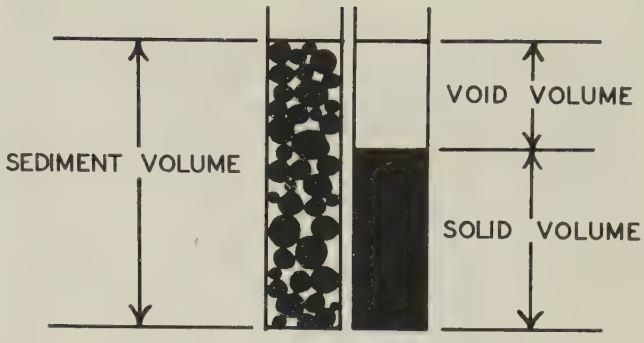

Fig. 2

lation of particle clusters is not a mechanical, but a chemical one. The prevention of flocculation is accomplished by bringing into the pigment system chemicals which act at the surfaces of the particles to make the particles mutually repellant. The use of chemical dispersing agents is an essential part of the dispersion process, in making efficient the use of mechanical energy and in lowering the viscosity of the pigment slurry. The relation between the chemical and mechanical aspects of dispersion is that the disruption of the particle clusters is the result of mechanically applied forces, while the prevention of the reversible rebuilding of particle clusters (flocculation) is the result of chemical dispersing agents. Implicit in this statement is the opinion that chemical action of dispersion must be preceded by mechanical disruption of the particle clusters.

A coating color consists of a suspension of pigment particles in a fluid medium. A concept of importance is that the adhesive and all other dissolved materials are a part of the fluid in which the pigment is suspended. The adhesive profoundly affects the viscosity of the suspending fluid, but has only a small influence on the particle interaction. The water-adhesive fluid acts as a lubricant between particles, and enables them to slide over each other much more easily than could dry particles. If there is not enough fluid available to fill up all the void spaces, there must necessarily be dry solid particles sliding against each other, and the consistency will be that of a viscous paste or damp powder. By reducing the void volume, as for example by dispersing the pigment particles to eliminate aggregates or flocs, a formerly insufficient amount of fluid can become sufficient to fill the void volume, furnishing a lubricating film of fluid between all of the particles.

Such a transition is pictured in Fig. 1 in which is represented the separation (deflocculation and disaggregation) and rearrangement of a few enlarged particles, in the presence of a limited amount of water. The diagram is intended to illustrate in two dimensions the type of process which, occurring in three dimensions, accounts for a change in consistency in a pigment water mixture from a damp powder to a viscous liquid, with no change in composition (*1*, *2*).

The mechanical interaction between particles, which occurs during dispersion, and which inter-relates dispersion to viscosity is controlled by the volume concentration of the pigment. The volume concentration of the pigment is related to the weight concentration, through the density of the pigment, but general expressions applicable to all pigments can only be made in terms of volume concentration. For this reason, charts showing volume concentration are not specifically marked, but charts showing weight concentration must identify, or indicate the density of, the specific pigment.

SEDIMENT VOLUME

The sediment volume is the volume which the pigment occupies when the particles are resting against each other, as shown diagrammatically in Fig. 2. If the particles are stuck together, and cannot find holes in which to fit, the sediment volume will be large. If the particles are separate from each other, they will arrange to leave a minimum of empty space and sediment volume will be small. If the pigment-liquid mixture is to have the properties of a fluid suspension, the void volume between particles and clusters of particles must be filled with liquid, and a further increment of liquid in addition must be present, to suspend the particles and separate them from each other. By this concept, the sediment volume is related to the flow behavior of a pigment-liquid mixture. Furthermore, the process of dispersion of an agglomerated pigment may be considered to be the process of reduction of the sediment volume.

It is important to note that relative sediment volume is completely independent of particle size, although affected by the ratios of particle dimensions and proportions present. A high relative sediment volume of very small particles is an indication of a high degree of particle agglomeration just as it is with large particles.

The term "sediment volume" is used because sedimentation from a suspension is the most obvious way to determine the volume which will be occupied by the pigment when the solid particles are as close together as they can get without changing their agglomerate structure. In such a determination of sediment volume, the suspended pigment settles to the bottom of the containing tube, either under the influence of gravity or of

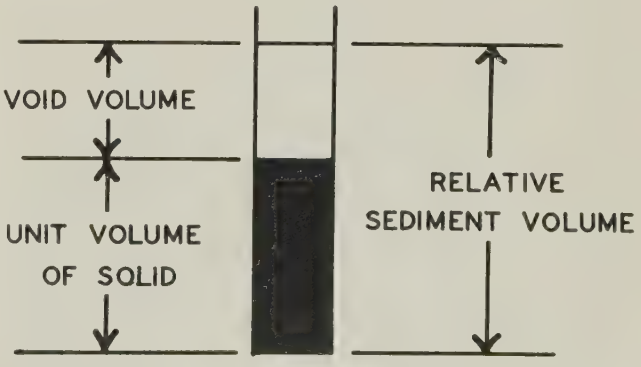

Fig. 3

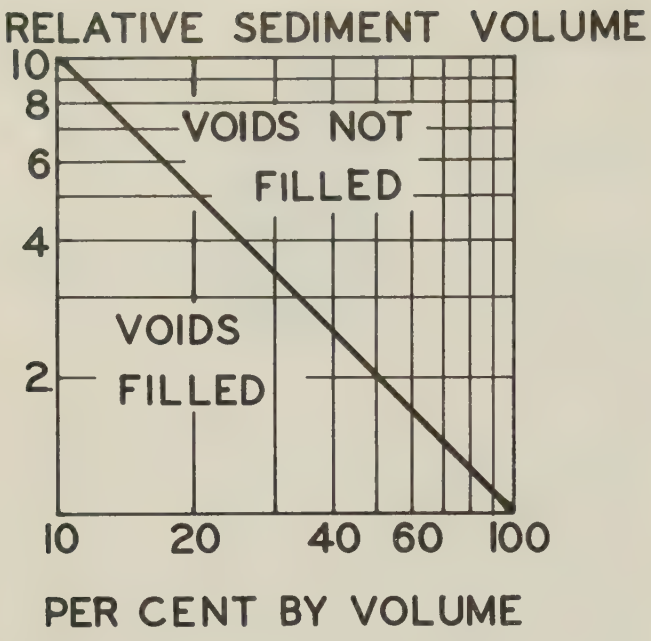

Fig. 4

centrifugal force, forming a sharply demarcated sediment under a clear supernatant liquid. If the supernatant liquid is decanted from the sediment, the sediment will have a certain composition, which may be expressed as "per cent solids," and this will be the composition at which there is just enough liquid present to fill exactly the void spaces between and inside of particle agglomerates. The same "sediment" condition may be reached in a process of dispersion, in which there is no change in composition, but during which the void space decreases until the liquid present, initially insufficient, equals in volume the void volume. The volume relationship found in a sediment is thus identical to a unique point in the dispersion of a pigment in the presence of a limited quantity of liquid.

Considering the case of a sediment, an algebraic relationship exists between the relative sediment volume and the solids content. The assumptions are that there is no swelling of the pigment by the liquid, that the volume of liquid present is just that required to fill the spaces between the particles, and that the particles or clusters of particles are resting against each other. The "solids" refers to the solid pigment, and does not include material which may be dissolved in the liquid. With these limitations, the following equations are true:

$$\bar{S} = (1/d_S - 1/d_L) + 100/(d_L)\,(\%\ \text{solids}) \qquad (1)$$

$$S' = (1 - d_S/d_L) + 100\ d_S/(d_L)\,(\%\ \text{solids}) \qquad (2)$$

$$S' = d_S\bar{S} \qquad (3)$$

$$S'V = 1 \qquad (4)$$

$$V = \frac{(\%\ \text{solids})/d}{(100 - \%\ \text{solids})/d_L + (\%\ \text{solids})/d_S}$$

$\bar{S}$ = specific sediment volume = (sediment volume)/(weight of solids).
S' = relative sediment volume = (sediment volume)/(volume of solids).
d_S = density of the solids.
d_L = density of the liquid.
Solids, % = 100 (weight of solid)/(weight of solid + weight of liquid).
V = (volume of solid)/(volume of solid + volume of liquid).
100 V = per cent by volume of the solid.

The simple relationship between relative sediment volume and volume concentration, under the conditions of a sediment, may be derived by considering Fig. 3. In Fig. 3 the definition of relative sediment volume is expressed diagrammatically. By further definition, the volume concentration V is the ratio of the volume of solid to the total volume. Referring to Fig. 3, it is seen that the volume of solid is 1, and the total volume is the relative sediment volume S'. Therefore, by the two definitions, $V = 1/S'$, or $S'V = 1$, or $S' = 1/V$.

THE DISPERSION DIAGRAM

This special case, namely, that of the packed sediment, and the relationship that $S' = 1/V$, establishes a reference line for expressing the degree of dispersion of a pigment.

To visualize the reference line for dispersion, a graph may be plotted as shown in Fig. 4, in which relative sediment volume is the ordinate and per cent by volume is the abscissa. Plotted logarithmically, as shown, the function $S' = 1/V$ becomes a straight line, with a negative slope. To refer the condition of a particular pigment-liquid mixture to the graph, the relative sediment volume of the pigment, and the volume concentration of the pigment in the mixture, must be known. Note that the volume concentration V or per cent by volume, 100 V, is computed from the relationship that V = (volume of solid)/(volume of liquid + volume of solid) and that volume of air, or total volume, are ignored.

A property of the graph is indicated in Fig. 4. The line plotting $S' = 1/V$ is called the "packed sediment line" since the relationship is true only for a sediment, as defined above. All points below the packed sediment line are descriptive of pigment-liquid mixtures in which liquid is present in excess of that required to fill the void volume between particles, and the mixture is a suspension. The greater the distance below the packed sediment line, the more fluid and less viscous will be the suspension which a point represents. All points above the packed sediment line are descriptive of pigment-liquid mixtures in which the void space between particles is greater than the volume of water present. The void volume not filled with water will be filled with air. Such pigment-liquid mixtures are not fluids at all in the ordinary sense, since there is no continuous liquid phase.

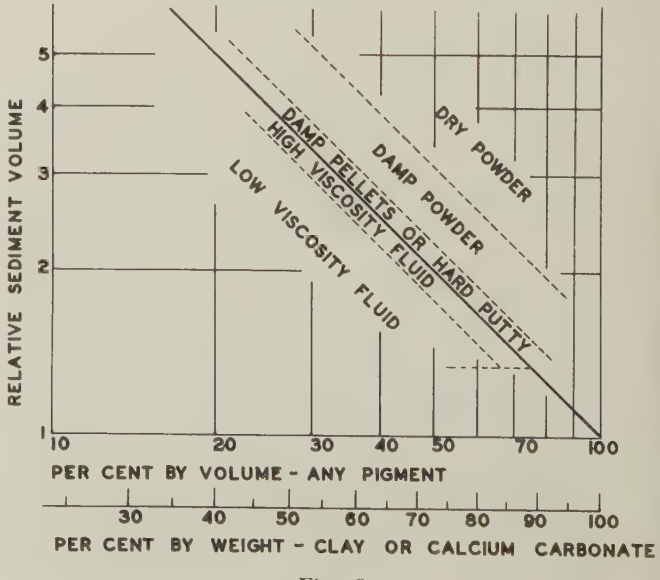

Fig. 5

Another property of the graph is that each point on it represents a flow behavior, or viscosity, since S' and V are determining parameters for the viscosity of a pigment suspension in any given liquid, in the same manner as for spheres (*3*). The packed sediment line is the dividing line between fluids and nonfluids.

The relation between flow behavior of a pigment-liquid mixture, and the point on the graph which describes it, is further illustrated in Fig. 5 which shows the sequences of the change of flow characteristics with position on the graph. Starting in the upper right hand corner, beginning with a dry powder, a decrease in solids, or a decrease in relative sediment volume, or both causes the mixture to become wetter and wetter, passing through the stages of damp powder, to damp pellets or hard putty, to the packed sediment condition, then into the region of fluids. Just below the packed sediment line is the very viscous region, most often accompanied by dilatant behavior, such flow being characteristic of suspension in which there is a very small excess of liquid over that required to fill the void spaces between the particles (*2*). Further decrease in either sediment volume or solids concentration progressively reduces the viscosity of the suspension.

The concept that the process of dispersion consists of reduction in the relative sediment volume of a pigment may be further elaborated by showing a typical dispersion process, charted on the dispersion diagram in Fig. 6. In this instance, the process consists of adding water and chemical disperser to dry clay until a fluid suspension is formed, and then agitating the mixture vigorously with a high-speed impeller of some sort. On the dispersion diagram, dry clay is represented on the 100% solids line, with a sediment volume represented as 3.5. The process of diluting reduces the solids content, but does not change the sediment volume. This way of showing the process is not quite accurate because the volume of the dry clay is considerably greater than that of the wet, due to bridging and electrostatic repulsion of the dry particles. However, the graph conveys the idea that no disagglomeration occurs simply as a result of diluting. Disagglomeration does occur, however, as a result of vigorous agitation of the suspension, shown on the diagram by a reduction in sediment volume from 3.5 to 2.1. This reduction in sediment volume is accompanied by a reduction in viscosity. The final value of relative sediment volume is a function more of the ease of dispersion of the pigment than of the mechanical action, because, at this low solids content, only forces of a low magnitude will reach the individual agglomerates. Strongly bound agglomerates will not be affected even by very powerful agitation, and the energy of agitation will be expended in viscous friction rather than against the suspended particles.

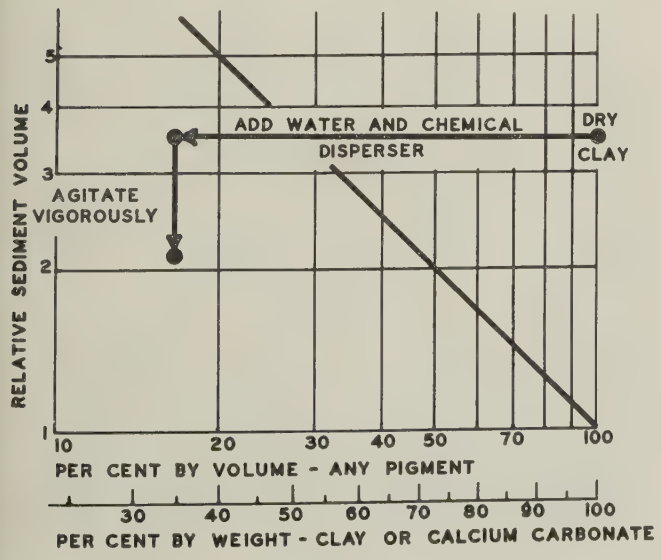

Fig. 6

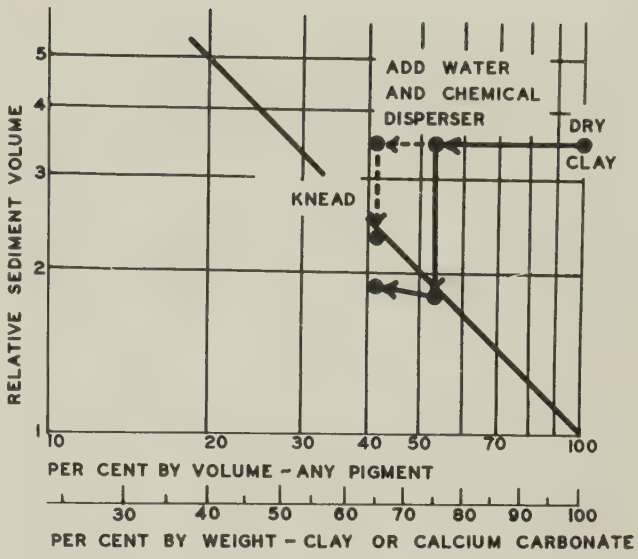

Fig. 7

A process of dispersion at high solids is shown on the dispersion diagram of Fig. 7. Dry clay is diluted with water and chemical disperser to a concentration of 53% by volume or 75% by weight of solids. This mixture will have the consistency of damp powder. Kneading causes the abrasion of particles against each other, with the disruption of the agglomerates and the reduction of relative sediment volume. When the liquid present is in excess of that required to fill the void volume, the mixture becomes fluid and the slow moving arms of the kneader cause little further disaggregating action. The dispersion progresses, therefore, to a point just below the packed sediment line. The final step presented in Fig. 7 is a dilution and the slight rise in relative sediment volume shown is intended to suggest that flocculation took place upon dilution. Such a flocculation is commonly observed and is presumably due to a change in the stabilizing layer around each particle, formed by the adsorbed dispersing agent.

An alternate process is shown by the dotted lines on the diagram of Fig. 7. The clay in this process was diluted to its final solids immediately, and then kneaded. The dispersion accomplished by the kneader still takes the relative sediment volume to a point just below the packed sediment line, but at the lower solids content. The clay kneaded at high solids and then diluted is shown as having a lower relative sediment volume than the clay diluted and then kneaded. The behavior diagrammed accounts for the lower adhesive demand of pigments dispersed at high solids, compared to pigments dispersed at low solids. The relationship of relative sediment volume to adhesive demand is not in accord with the idea that high solids dispersion imparts a

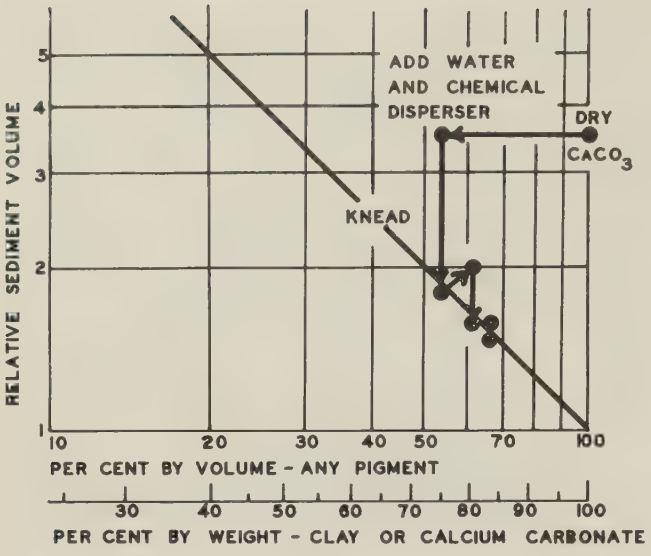

Fig. 8

peculiar property to the surface of the pigment (*4*). The assumption in the diagrams of Fig. 7 is that this particular clay exists in aggregates which require strong mechanical forces to disrupt them. If the clay were not aggregated, it is quite likely that nearly equal relative sediment volume would result from either process. It may be noted that relative sediment volume is being used as a quantitative measurement of the degree of dispersion.

Another process of dispersion is shown in Fig. 8 in which water and chemical disperser are added to a coating grade of calcium carbonate pigment, and the mixture kneaded as before. To this dispersion, more dry calcium carbonate is added, raising both the solids and the relative sediment volume, as shown on the dispersion diagram. Kneading again reduces the relative sediment volume to a point just below the packed sediment line. The process may be repeated, as indicated, until the limit of disagglomeration is reached. As the limit is approached, the points after kneading will come closer and closer to the packed sediment line. An important point, which is self-evident, is that there is an irreducible minimum in relative sediment volume, characteristic of each pigment sample. The purpose of repetitively kneading, raising solids, and kneading again, is to determine experimentally this minimum sediment volume.

THE APPLICATION OF MECHANICAL FORCE TO BRING ABOUT DISPERSION

The dispersion of aggregates is brought about by the application to the aggregate of a force greater than bonds between the component particles can withstand. The power used to effect disaggregation may not be relevant to the results achieved. Neither power nor total work determines whether disaggregation occurs, but rather the force reaching each aggregate. It is frequently true that the greater the power input into a given charge, the greater is the force which each aggregate will experience. An exception is the case of dilute suspensions, to which it is possible to supply high power input, by means of high-speed agitators, without subjecting individual aggregates to forces large enough to disrupt them. The power in such a case in used to pump the fluid, and is dissipated as heat resulting from viscous work, not interparticle friction.

On the other hand, very large forces can be applied to aggregates at the expenditure of very modest power. Devices which localize the power input to a small volume are the means for such disaggregation. The edge runner, or kollergang, is such a device. Impact mills are other means of applying the principle. The colloid mill is intended to operate on this principle, and will do so, provided that the concentration of solids can be maintained high enough that interparticle friction is substantial. Even the best colloid mill will accomplish little disaggregation if the solids are so low that particle interaction is small. The gap in a colloid mill can seldom be maintained as small as the dimensions of the coating pigment particles.

Such a machine which concentrates power on a small volume requires a longer time to disaggregate a large volume of material than does a machine which applies high power to a large volume, but given the time it will accomplish the job. By contrast, a machine which supplies a low power to a large volume of material will never accomplish disaggregation, because the maximum forces which each aggregate experiences will never exceed the force required for disruption. The determining factor is power input per unit volume of material in the effective zone of the machine, with the qualification that the power be dissipated in interparticle friction, not viscous friction.

The packed sediment condition, shown by the reference line on the dispersion diagram, permits mechanical power to be applied most effectively. In this condition, any force of shear applied to the sediment causes a rearrangement of particles and an increase of volume, so that the liquid within the void volume is no longer sufficient to fill the void volume and air-liquid interfaces are created. The surface tension of the water exerts a powerful force pulling the particles against each other in opposition to the applied mechanical force tending to pull the particles apart.

The action of mechanical shearing under these circumstances is somewhat similar to a squeezing action, as in a vise, which will force the particles to break apart if they are struck together, to permit a reduction of the

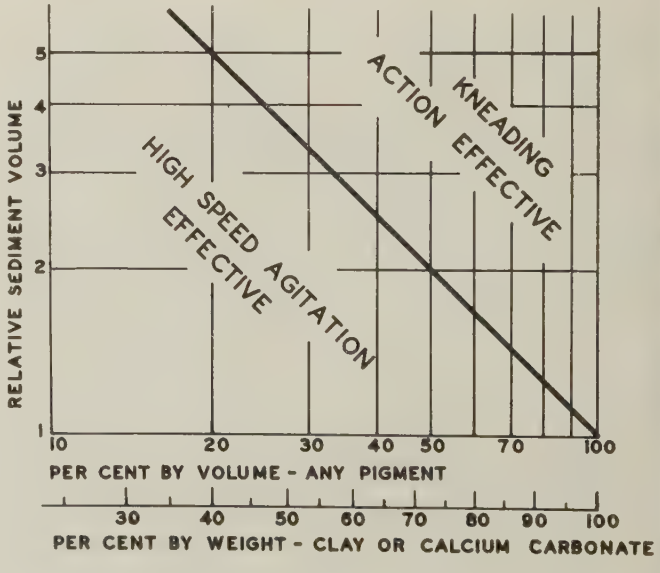

Fig. 9

Table I. Effect of Solids on Dispersion in a Kneader of an Agglomerated Calcium Carbonate (0.2% Metaphosphate Dispersing Agent)

Solids at which dispersed — By weight, %	Solids at which dispersed — By volume, %	Relative sediment volume — centrifugal sedimentation
40.0	20.0	3.10
53.5	30.3	2.94
53.7	30.5	2.86
56.8	33.3	2.78
56.6	33.1	2.70
57.7	34.1	2.68
59.1	35.4	2.60
60.4	36.6	2.55
60.7	36.8	2.47
61.0	37.1	2.41
66.9	43.3	2.23
74.7	52.9	1.80
75.3	53.6	1.86
75.9	54.4	1.80
76.2	54.6	1.77
78.8	58.3	1.70
80.4	60.8	1.62
81.1	61.7	1.62
82.0	63.2	1.62
82.3	63.7	1.59

total volume. In the case of higher solids, in which an appreciable proportion of the void space between particles is full of air, the surface tension effect is greatly reduced and the particles slide over each other with a smaller interaction.

On the other hand, if there is a large volume of liquid present, the agglomerates are separated from each other, there is no surface tension effect, and the particle interaction is also small. The situation is somewhat analogous to swatting flies: Each particle must be individually hit to be disagglomerated.

The application of mechanical means for dispersion may thus be generalized as in Fig. 9, using the dispersion diagram for a map. In the area above and closely below the packed sediment line, kneading or viselike action is effective, while below the line, except in the immediate vicinity of the line, high-speed agitation or fly-swatter action is effective in bringing about pigment dispersion.

As the size of the aggregates decreases, the difficulty

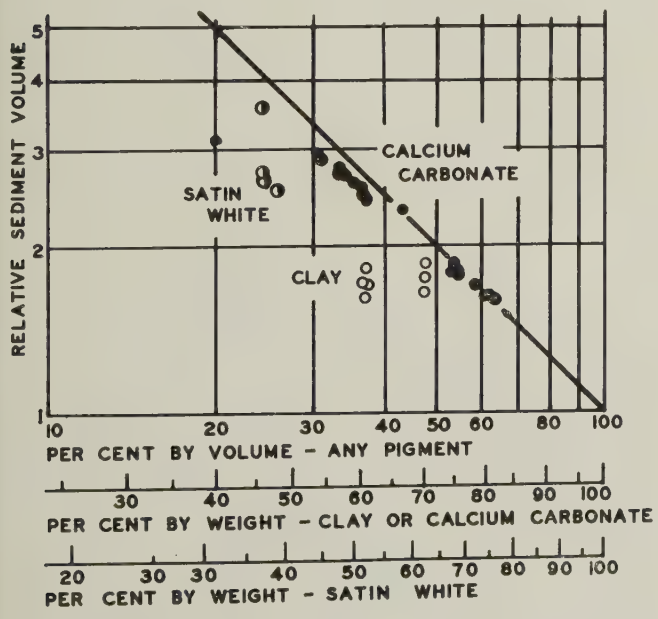
RELATIVE SEDIMENT VOLUME
5
4
3
2
1
CALCIUM CARBONATE
SATIN WHITE
CLAY
10 20 30 40 50 60 80 100
PER CENT BY VOLUME - ANY PIGMENT
30 40 50 60 70 80 90 100
PER CENT BY WEIGHT - CLAY OR CALCIUM CARBONATE
20 30 30 40 50 60 70 80 90 100
PER CENT BY WEIGHT - SATIN WHITE

Fig. 10

Table II. Dispersion of Coating Clays in a Kneader

Clay	Dispersing agent %	Solids at which dispersed — By weight, %	Solids at which dispersed — By volume, %	Relative sediment volume centrifugal sedimentation
Low viscosity, clay no. 1	0.35	70.2	47.1	1.65
	0.50	70.5	47.5	1.86
	0.35	60.4	36.6	1.72
	0.50	61.0	37.1	1.70
Low viscosity clay no. 2	0.35	70.4	47.4	1.75
	0.50	70.3	47.2	1.64
	0.35	61.0	37.1	1.83
	0.50	60.8	37.0	1.61

increases of providing an environment in which the aggregate will receive a force sufficient to break them. For example, if a torsional stress is to be applied to the bonded area, it must be applied through the particles on each side of the bond, and as their length decreases, the greater is the force required to achieve the same moment of torque. A further difficulty is encountered in reaching small aggregates with high stresses, considering that their size may be far smaller than the scratches on the surfaces of the machine parts in contact with them. The obvious means for reaching such small particles is to cause then to wear against each other.

ILLUSTRATIVE EXPERIMENTS

Coating grade calcium carbonate was dispersed in a kneader in a series of experiments in which the solids during kneading were varied. The relative sediment volume after dispersion was measured, by centrifuging a sample of the suspension and measuring the volume of the sediment. The results are shown in Table I, and in Fig. 10 (solid circles). At low solids level, the points fall below the packed sediment line, and as the solids are raised, the points come closer to the packed sediment line. The calcium carbonate was firmly aggregated, and disaggregation occurred only when conditions permitted the application of maximum force to disrupt the aggregates, namely, in the condition of a packed sediment.

By contrast, a disaggregated coating clay was similarly dispersed in the kneader, at two solids levels, and with two levels of tetrasodium pyrophosphate dispersing agent. The results are shown in Table II and Fig. 10 (open circles). Solids level had no effect upon the sediment volume, indicating that only a small amount of mechanical work was required to cause dispersion. Sediment volume was affected by the amount of chemical disperser, indicating that the flocculating tendency of the particles was the factor controlling sediment volume. One could infer from the position of the points representing clay on the dispersion diagram that an increase in solids to about 76 or 77% by weight would bring the clay into the packed sediment condition, and kneading at this high solids would demonstrate whether

Table III. Dispersion of Satin White in a Kneader

Dispersing agent	Solids at which dispersed — By weight, %	Solids at which dispersed — By volume, %	Relative sediment, volume — centrifugal sedimentation
5% A	36.6	24.2	2.73
5% A plus 1% B	36.8	24.4	2.64
5% A plus 1% C	39.6	26.8	2.52
5% A plus 1% D	36.6	24.2	3.57

the measured lowest relative sediment volume of 1.61 was the minimum possible with this clay, or whether further disaggregation could take place.

A study of the effectiveness of several dispersing agents for satin white was made, by kneading the satin white at one solids level, with the various dispersing agents. The results are shown in Table III and Fig. 10 (shaded circles). The distance of the plotted points from the packed sediment line indicates that the dispersion of satin white, to the degree represented by a relative sediment volume of 2.52, was a matter of deflocculation rather than disaggregation. The slow moving arms of the kneader were not applying much force to the individual particles, in such a fluid condition, but the best dispersing agents caused a large reduction in relative sediment volume. Evidence (not here shown) that the satin white is not substantially aggregated, is that raising the solids, as by low-temperature drying, followed by kneading, in the packed sediment condition, lowered the relative sediment volume to 2.0. This high relative sediment volume of satin white appears to be the result of the inability of the needle-like crystals to pack closely.

These experiments illustrate the points that aggregation may be studied by means of relative sediment volume as with the calcium carbonate, but other factors affecting relative sediment volume are flocculation, as in the case of the clay, and the intrinsic ability of the crystal particles to pack, as in the case of the satin white.

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Molecular Association in Starch Films

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The "molecular architecture" within a dried starch film influences its behavior as an adhesive or as a sizing agent for paper or textiles. A simple method is described for evaluating both the extent and the strength of associative bonding in free starch films, by determining their solubilities in water over a temperature range of 30 to 90°C. Thus a dried film of unmodified corn starch is extensively and strongly associated, with low solubility even at 90°C. In contrast, films of waxy white milo starch are extensively but weakly associated, being insoluble at low temperatures but soluble above 50°C. Strong association is due primarily to the linear starch fraction. The branched fraction can likewise associate, particularly in films dried at low temperature, but this is a weak type of bonding analogous to the staling of bread. Similar techniques are applied to evaluate the film architecture of thin-boiling starches, potato starch, the oxidized and derivatized starches, as well as the effect of cross-bonding the original granular starch and the final films.

Most of the industrial uses of starch products involve cooking of the starch in water, application of the resulting paste or solution to a solid surface, followed by drying of the film or coating. The function of the starch may be as an adhesive (to cause two surfaces to stick together), or the cooked starch solution may be used to give a smooth coating over a solid surface. The following industrial applications of starch are cited as examples of these two functions:

1. A paper sheet or a textile fabric may be coated with a solution of starch, to lay fuzz, to give a smooth continuous surface (e.g., more resistant to soil or grease), and to improve the "feel" or finish of the product.
2. A gelatinized starch paste is added to the beaters in papermaking. The swollen starch granules filter off and lodge in the mat of fibers when the paper sheet is initially formed, and then dry down to produce the requisite fiber-to-fiber bonding.
3. As an analogous instance, pregelatinized starchy flours are used as foundry core binders, which are mulled into wet sand to coat each sand grain. The mixture is then molded and dried, the sand grains adhering to one another because of the adhesive action of the intervening dried starch film.
4. Starch solutions are used in the clay coating of paper, simultaneously acting as a surface coating and as an adhesive for the clay and pigment (*1*, *2*).

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In each instance, the starchy coating must have certain specific physical properties to qualify it for the intended use. These properties include such factors as water solubility, adhesion of the coating to various surfaces, film transparency, plasticity, and internal strength. Frequently, different applications will require the starch coating to exhibit diametrically opposite properties; for example, the film of remoistening gum on an envelope flap should be immediately soluble in cold water, while a corrugating gum should be water resistant.

In all of these varied applications, the utility of the starch is influenced by two critical factors: (1) the adhesion of the dried starch film to the solid surface, and (2) the organization or "molecular architecture" of the starch substance within the dried film or coating. This second factor, in turn, will be influenced by two considerations: (1) the size and shape of the starch molecules, and (2) the extent and strength of associative bonding between molecules. For example, where the associative bonding between starch molecules is low, it might be anticipated that the dried film will have lower tensile strength and higher plasticity than a highly organized film. Very little attempt has been made to study the bonding within dried starch films. One of the few pertinent investigations is that of Bradbury (*3*), who evaluated the associative bonding in textile warp sizings by measurement of the rate of solubilization of the starch by enzyme. With the

advent of many new types of starch modifications and derivatives (many of which are designed to reduce the natural retrogradation tendency of the starch), it becomes imperative to develop a better understanding of the molecular architecture within the film, the manner in which this organization is altered by prior modification of the starch, and how these factors influence the particular end-use of the product.

The present investigations have been concerned primarily with the organization of the starch substance within the film, and not with the adhesion of the coating for solid surfaces. Hence, studies have been devoted to free starch films, to avoid any adsorption or mechanical entrapment of the starch which might occur if coated on a cellulosic base. It has been found that cold-water solubility of the dried film provides a satisfactory criterion of the *extent* of molecular association within the film. Thus a film in which the molecules are completely dissociated will be entirely soluble in cold water. If any of the starch substance is associated (i.e., either retrograded, or chemically cross-bonded, or in the form of dried swollen granules or fragments of granules), then this material will be insoluble in cold water. In addition, the *strength* of this associative bonding can be evaluated by determining the solubility in water at elevated temperatures, which disaggregates the more weakly associated starch. By determining the solubility of the film at various temperatures from 30 to 90°C. and then plotting percentage of soluble starch versus temperature, a curve is obtained which is descriptive of both the extent and the strength of associative bonding within the film.

EXPERIMENTAL PROCEDURES

Plating of Films

With certain types of modified starch the amount of soluble starch which can be water-leached from the film is influenced by the thickness of the film, thicker films giving somewhat less solubles than thinner ones. Consequently, an effort was made to cast all films to give a dry thickness of approximately 1 mil. The various starches necessarily had to be cooked at widely different concentrations to accomodate their different viscosities, which necessitated regulation of the thickness of the wet film. A variable applicator (as shown in Fig. 1) was fabricated from stainless steel, with an adjustable spreader bar whose position could be readily preset by placing the applicator on a flat-ground plate, spacing the spreader bar with a thickness gage at each end, and tightening the wing nuts. Films were cast on polished stainless steel plates. The latter were first dipped in a 3% solution of silicone resin (Dow Corning XR-671) in toluene, drained, air-dried, and cured for 1 hr. at 230°C. This gave a surface from which the films released readily on drying. Starch pastes of appropriate concentration were adjusted to pH 6.0 and cooked for 1 hr. in the boiling water bath with continuous mechanical stirring, then plated out at the desired thickness on the stainless steel plates.

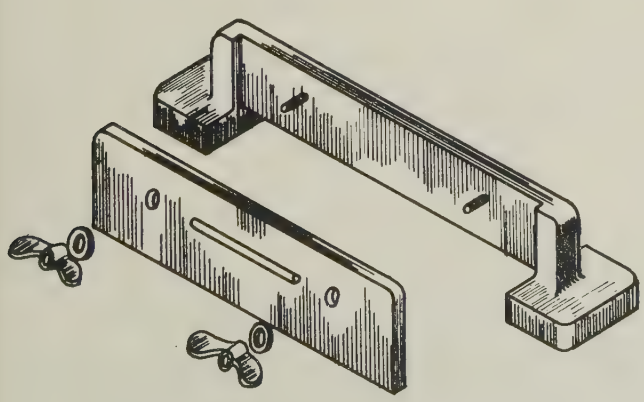

Fig. 1. Design of film applicator. Overall length is 7 in.

Drying of Films

Films have been dried both at room temperature and in the circulating air oven at 80°C. Preliminary results with room-temperature drying gave wide differences in the amount of soluble starch extractable from the dried films, which was traced to variations in the rate of drying. Rapidly dried films showed substantially higher solubles than slowly dried films. For example, a white dextrin film dried slowly in still air at room temperature tested 18% solubles; an identical film dried in a rapid current of air from a fan showed 32% solubles. In order to standardize the conditions of drying, an air-tight cabinet was constructed to hold a number of the stainless steel plates. Air was pumped from the cabinet and bubbled through a saturated solution of an appropriate salt, then through a spray trap and back into the cabinet. Wet-and-dry bulb thermometers were placed at both the entrance and exit to the drying cabinet, to indicate when moisture equilibrium was established. Using saturated potassium carbonate solution (i.e., equilibrium at 43% R.H.), a linear rate of drying of the films to an equilibrium moisture content of 13% was achieved in 3 hr. Using saturated lithium chloride solution (15% R.H.), a linear rate of drying to 10% moisture was obtained in 2 hr. The latter system was used with all room-temperature dried samples herein reported; this mode of drying under standard conditions gave good duplicability of results on replicate films.

In certain instances, films have likewise been slowly dried in the refrigerator at 4°C., to determine the effect of retarded drying at low temperature. In addition, several laboratory-prepared roll-dried starches were included, as representative of commercial pregelatinized products. These were prepared by cooking the starch for 15 min., then drying the paste on 6-in. steam-heated squeeze rolls.

In all cases, the dried films were subsequently ground in a Wiley laboratory mill, screened, and that fraction between 50 and 100 mesh then taken for solubility studies. Tests showed that material coarser than 50-mesh gave somewhat lower solubles, while material finer than 100-mesh had slightly but significantly higher solubles.

Determination of Solubles

A 1 g. sample of the ground film was suspended in exactly 35 ml. of water in a 50-ml. Erlenmeyer flask fitted with a glass stirring propeller and a loosely-fitting collar to minimize evaporation. The suspension was placed for 1 hr. in a thermostated bath at the desired temperature, meanwhile stirring mechanically at a rate just sufficient to keep all the film particles suspended. Excessively rapid agitation may break up the film particles and give a fictitiously high value for

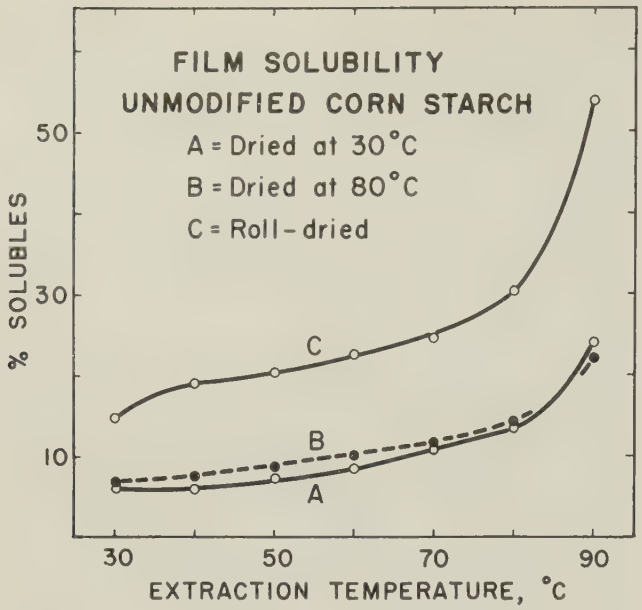

Fig. 2. Film solubility of unmodified corn starch, (A) dried at 30°C., (B) dried at 80°C., and (C) roll-dried

starch solubles. Longer extraction time (viz., 2 hr.) gave identical percentage solubles. The suspension was then transferred to tubes and centrifuged for 20 min. at 1800 r.p.m. The supernate was withdrawn, and solubles determined on an aliquot by either of two methods: (1) direct evaporation to dryness in a Vycor crucible and weighing on a semimicro balance, or (2) dilution to an appropriate concentration and evaluation of carbohydrate by a modified anthrone colorimetric method. The latter procedure was preferred, and the direct gravimetric method was employed only for occasional check determinations, or where the presence of an adjunct interfered with the anthrone reaction. The anthrone method was calibrated against three different modified starches (viz., 75-fluidity corn starch, a low-viscosity hypochlorite-oxidized starch, and a 75-fluidity hydroxyethyl starch of 0.1 D.S.); an identical calibration curve was obtained for all three products. Replicate determinations on single film samples showed a precision of ± 1.6% (expressed as average deviation from the mean percentage solubility). Precision on separately-prepared film samples was ± 3.2% solubility.

Concurrent observations on the swelling of granular starches (unpublished work by Harry W. Leach of this laboratory) have shown that it is sometimes difficult to differentiate sharply between dissolved starch substance (i.e., where the molecules are presumably monodispersed in "true" solution), and enormously swollen or hydrated aggregates. Hence it is possible that water dispersions of certain starch films (e.g., potato starch) may appear to be completely soluble when centrifuged at 1800 r.p.m., but will show the separation of a supernatant layer when centrifuged at 14,000 r.p.m. However, the latter situation would indicate a film bonding of extremely weak and tenuous character, which for present purposes is indistinguishable from complete dissociation.

Starches Tested

The following commercially available starches have been examined. In each case, films were dried at room temperature and at 80°C., and solubility curves were obtained at 10°C. intervals over the range of 30 to 90°C.

Unmodified thick-boiling corn starch.
Unmodified thick-boiling "white milo" starch, a variety of waxy sorghum.
Unmodified thick-boiling potato starch.
Acid-modified 80-fluidity* corn starch.
Acid-modified 80-fluidity "white milo" starch (waxy sorghum).
Hypochlorite-oxidized corn starch, 100-g. Scott viscosity = 55.*
Thin-boiling hydroxyethyl starch, 80-fluidity, 0.05 degree of substitution.
Thin-boiling hydroxyethyl starch, 80-fluidity, 0.1 degree of substitution.
Chemically cross-bonded "white milo" starch.
Corn white dextrin, 5% cold-water soluble.*

* Procedures for evaluating fluidity, Scott hot-paste viscosity and dextrin solubility of modified starches are described by Kerr (4).

In addition, tests were run on corn phytoglycogen, which is the native water-soluble polysaccharide present in yellow sweet corn.

RESULTS AND DISCUSSION

Films from commercial thick-boiling corn starch show relatively low solubility at all extraction temperatures (Fig. 2). The films slowly dried at room temperature are slightly less soluble than those rapidly dried at 80°C.; however, the two curves become virtually identical at extraction temperatures above 70°C. As

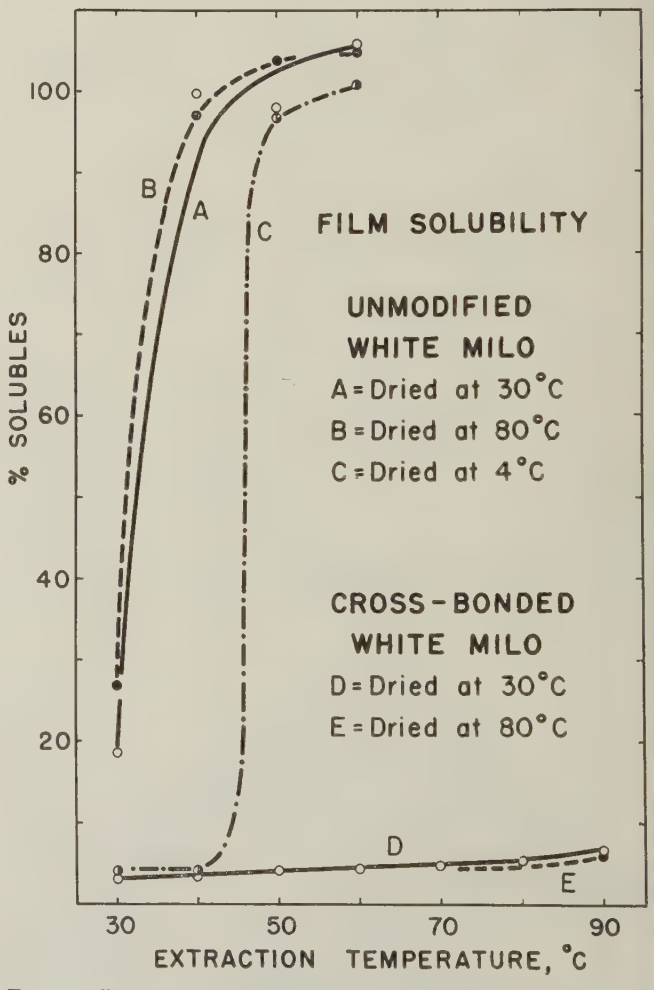

Fig. 3. Film solubility of unmodified white milo starch, (A) dried at 30°C., (B) dried at 80°C., and (C) dried at 4°C. Also, film solubility of cross-bonded white milo starch, (D) dried at 30°C., and (E) dried at 80°C.

a physical interpretation of these data, it appears that approximately 75% of the total starch substance is so strongly associated that it is not dissolved even at 90°C. This insolubility is attributed principally to the persistence of micellar structure in the starch granule, immobilizing starch substance within the swollen and dried granules. Approximately 6 to 7% of the starch substance in these films is molecularly dissociated and hence soluble at 30°C. The remaining 18% of the starch is moderately associated, being insoluble at 30°C. but soluble at 90°C. The slightly lower solubility of the film dried at room temperature represents association which occurs during slow-drying of the film. The much higher solubility of the roll-dried corn starch is attributed partly to the higher temperature and shorter time of drying, and partly to the shearing action of the rolls, which tends to tear apart and disperse the swollen granules.

Thick-boiling "white milo" or waxy sorghum starch gives a completely different solubility pattern (Fig. 3). The films are extensively associated, but this bonding is so weak that it is completely reversed merely by extracting at 40 to 50°C. The waxy starches are composed entirely of branched fraction (i.e., naturally devoid of linear molecules), and this weak association probably operates through hydrogen-bonding of the external branches of adjacent branched molecules. Since these branches are reputed to be only 25 to 30 glucose units in length, the strength of bonding would be much less than with linear molecules of some hundreds of glucose units in length. This weak type of association appears to be identical with that which occurs during the staling of bread (*5*). In the latter

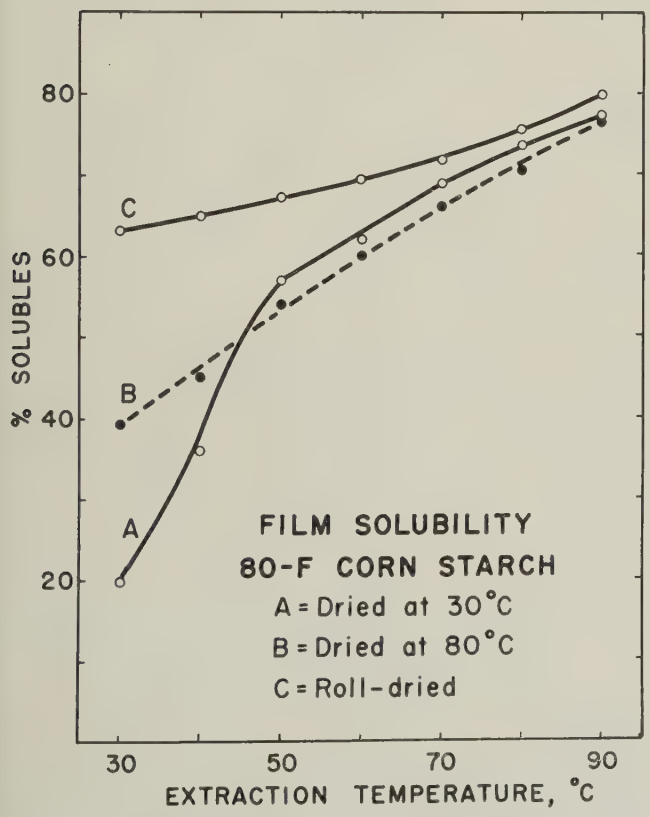

Fig. 4. Film solubility of thin-boiling 80-fluidity corn starch, (A) dried at 30°C., (B) dried at 80°C., and (C) roll-dried

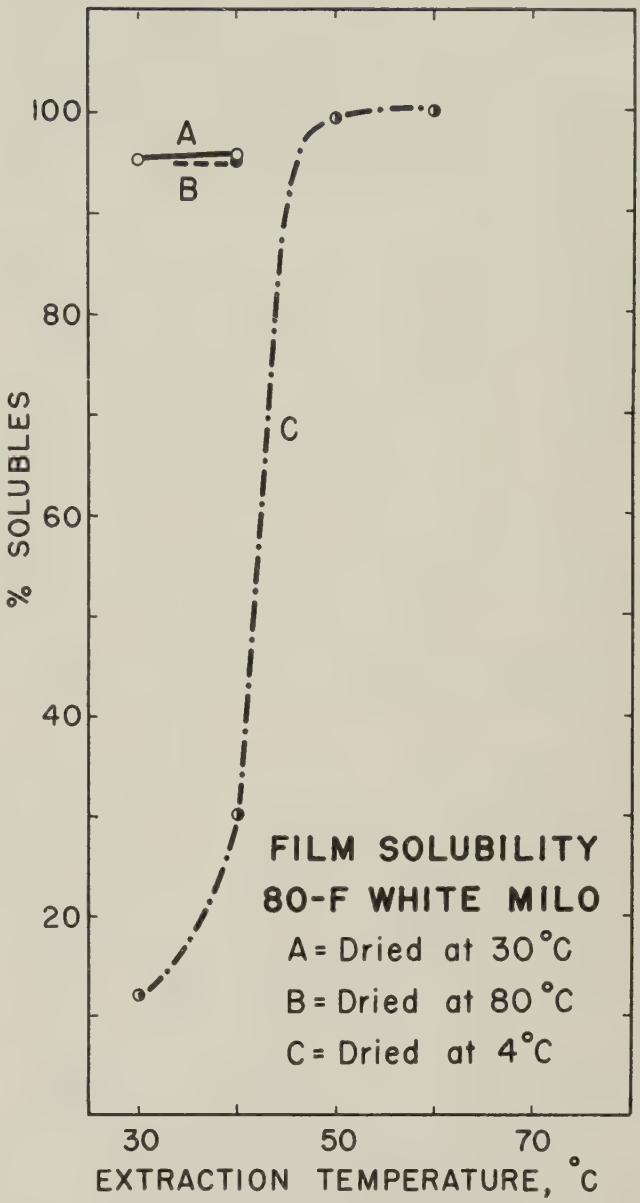

Fig. 5. Film solubility of thin-boiling 80-fluidity white milo starch, (A) dried at 30°C., (B) dried at 80°C., and (C) dried at 4°C.

case, the linear fraction retrogrades to an insoluble gel during baking and cooling of the bread, to impart a tender elastic structure to the crumb. The subsequent hardening which slowly develops in bread during storage is attributed to a weak but extensive association of the branched starch fraction. This is readily reversed by heating the bread to 50°C., analogous to the solubilization of the waxy white milo films at 50°C. This "staling" reaction is markedly increased by refrigerating the bread at 0 to 4°C.; similarly, films of white milo starch slowly dried in the refrigerator show substantially increased association (Fig. 3).

The solubility patterns of thin-boiling 80-fluidity corn and white milo starches (Figs. 4 and 5, respectively) parallel the behavior of the corresponding thick-boiling starches, but at a much higher solubility level. The process of acid modification has obviously weakened the internal micellar structure of the granules, so that they fragment on pasting and cooking in water. Hence, more of the starch substance in the cooked paste

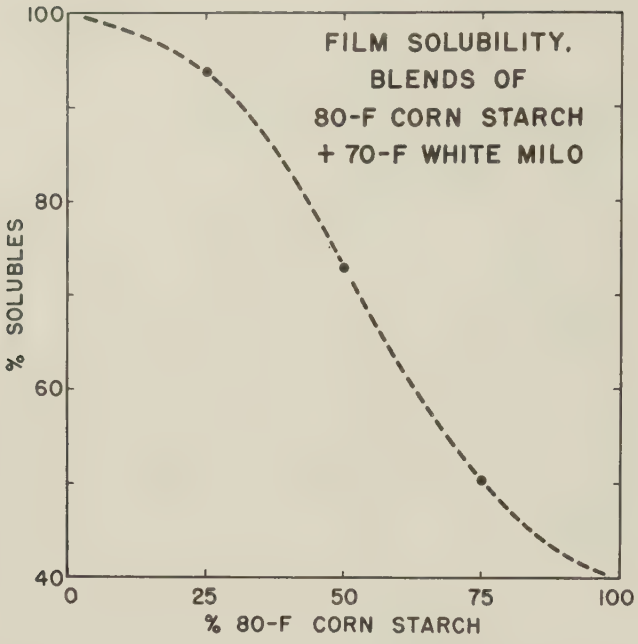

Fig. 6. Film solubility of blends of 70-fluidity white milo starch and 80-fluidity corn starch. Films dried at 80°C., and solubility determined at 30°C.

is in a dissolved state, and this higher solubility is carried over to the film. Films from 80-fluidity white milo starch are completely soluble at 30°C.; such thin-boiling waxy starches may therefore be used as a remoistening adhesive on labels, gummed tape, etc. Association is induced only by drying the film in the refrigerator (Fig. 5), but this "staled" film becomes completely soluble when extracted at 50°C.

The phytoglycogen from sweet corn is a highly branched type of glucose polysaccharide analogous in chemical structure to the branched starch fraction. However, the branches are much shorter (i.e., 9 to 11 glucose units in length), and consequently the molecular shape is much more compact, similar to a tight dense bush instead of the open tree like structure of the branched starch fraction (*2*). Due to its short branch length, this material shows no tendency whatsoever to associate. Thus phytoglycogen films were cast and slowly dried in the refrigerator at 4°C.; the product was completely soluble in water over the range of 30 to 60°C., and showed no evidence of the staling phenomenon of the waxy starches. Apart from its theoretical interest, phytoglycogen might be considered as typifying an ideal torrefaction dextrin.

Hence, the irreversible insolubility of corn starch films is attributed primarily to the influence of the linear fraction. This operates in two ways: (1) the presence of the linear fraction prevents breakdown and dissolution of the swollen granule during cooking of the starch paste and this structure in turn is carried over to the film, and (2) any dissolved linear fraction will retrograde during drying of the film, not only becoming insoluble itself, but likewise entangling the branched molecules in an insoluble network. That portion of the starch film which is soluble at 30°C. has been identified as composed of branched molecules of somewhat lower molecular weight. To establish this point, film prepared from an 80-fluidity thin-boiling corn starch was extracted with water at 30°C., both the soluble and the insoluble portions isolated by precipitation and dehydration with alcohol, and these materials then tested for iodine affinity and intrinsic viscosity (*6*):

	% Iodine affinity	*Intrinsic viscosity*
Original film	4.3	0.32
Insoluble portion	5.7	0.39
Soluble portion	0.8	0.20

The low iodine affinity of the soluble portion proves it to be almost entirely branched in structure; the lower intrinsic viscosity indicates smaller molecular size. The insoluble portion is apparently a mixture of branched and linear fractions, which gradually dissociates as the temperature is raised.

The associative bonding within a starch film can be controlled at the desired level by using the proper proportion of linear fraction, e.g., by blending normal and waxy starches. Thus, films have been prepared from various mixtures of 80-fluidity corn starch and 70-fluidity waxy white milo starch; the films were dried at 80°C. and solubilities subsequently determined at 30°C. Figure 6 shows the effect of increasing proportions of corn starch in reducing the solubility of the white milo films.

Most of the common methods of starch modification

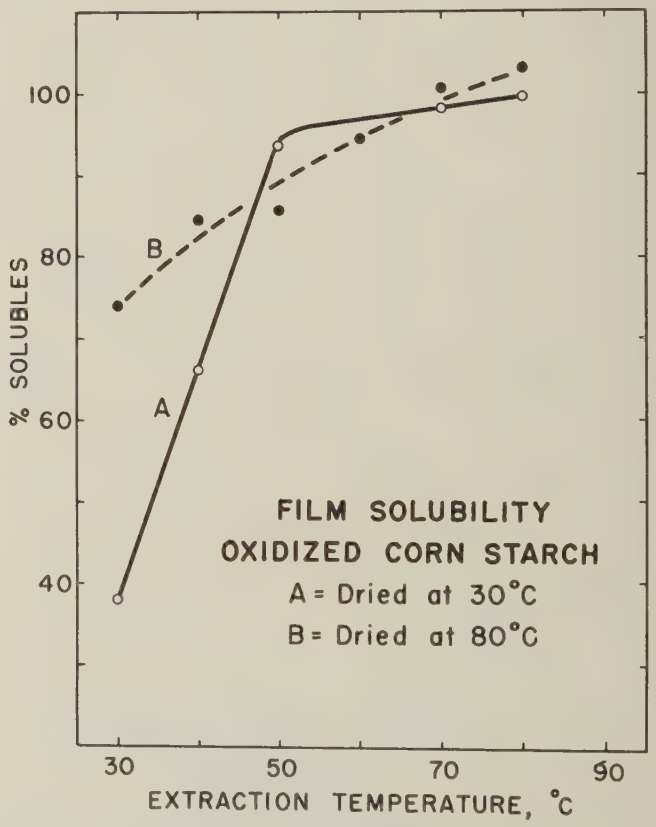

Fig. 7. Film solubility of hypochlorite-oxidized corn starch, (A) dried at 30°C., and (B) dried at 80°C.

accomplish either of two purposes: (1) reduction of paste viscosity to permit use of the starch at thinner fluidities or at higher solids, and (2) reduction of undesirable retrogradation of the linear fraction, to give more stable or more soluble products. Hypo-

chlorite oxidation of the starch achieves both objectives in one operation. Figure 7 shows the solubility patterns of films of a hypochlorite-oxidized corn starch, which are obviously dissociated to a substantially higher degree than films of a comparable 80-fluidity acid-modified corn starch. Another type of starch derivative which is coming into increasing use is the hydroxyethyl ether. The introduction of derivative groups along the linear molecules reduces the tendency of the latter to gel or retrograde. Hydroxyethylation does not alter the paste viscosity, and so it is customary to derivatize a thin-boiling starch of the desired fluidity. Figure 8 shows the solubility patterns of films from 80-fluidity hydroxyethyl starches derivatized to 0.05 and to 0.1 D.S. (i.e., degree of substitution, expressed as number of derivative groups per glucose unit). Film solubilities of the 0.05 D.S. product are substantially higher than values for a comparable acid-modified thin-boiling corn starch; the pattern of the 0.1 D.S. films is higher still, showing the advantage of higher derivatization in solubilizing the starch.

In contrast, chemical cross-bonding within the starch granule restricts subsequent swelling in hot water and greatly reduces solubilization of the starch substance. For example, Fig. 3 shows the solubility of films from a waxy sorghum starch which has been treated in the granular state to introduce ester cross-linkages between starch molecules (*7*). This starch undergoes only

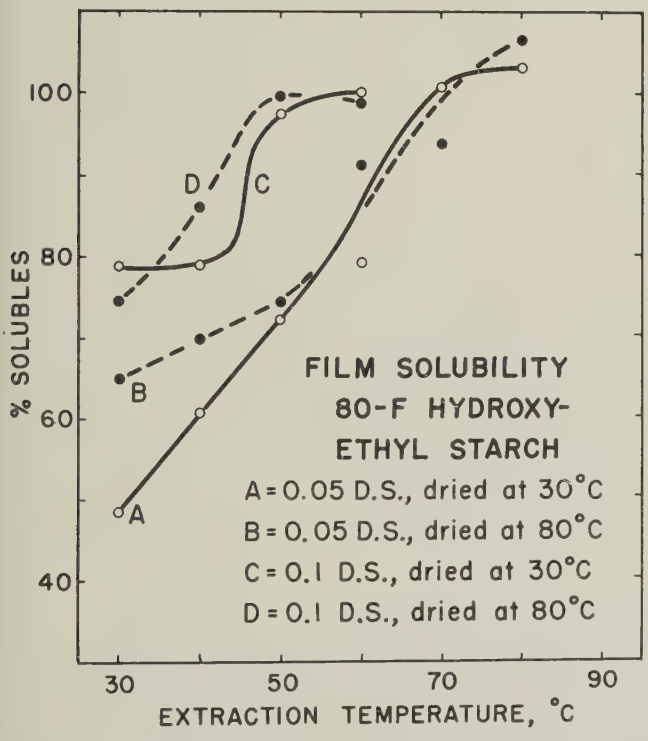

Fig. 8. Film solubilities of hydroxyethyl starches: (A) 0.05 D.S., dried at 30°C., (B) 0.05 D.S., dried at 80°C., (C) 0.1 D.S., dried at 30°C., and (D) 0.1 D.S., dried at 80°C.

limited swelling when cooked in water, to give a "short" heavy-bodied paste containing very little dissolved starch substance (*8*). These properties are reflected in the pattern of the final film; this insolubility is obviously due to chemical interlinking of the molecules and not to physical association. In agreement with observations by Belche and Cleek (*9*), a similar effect can be obtained by chemically cross-bonding the final film, e.g., by incorporation of urea-formaldehyde ("U-F Concentrate 85," marketed by Allied Chemical and Dye Corp., containing 59% forma dehyde and 26% urea). For example, an 80-fluidity corn starch was

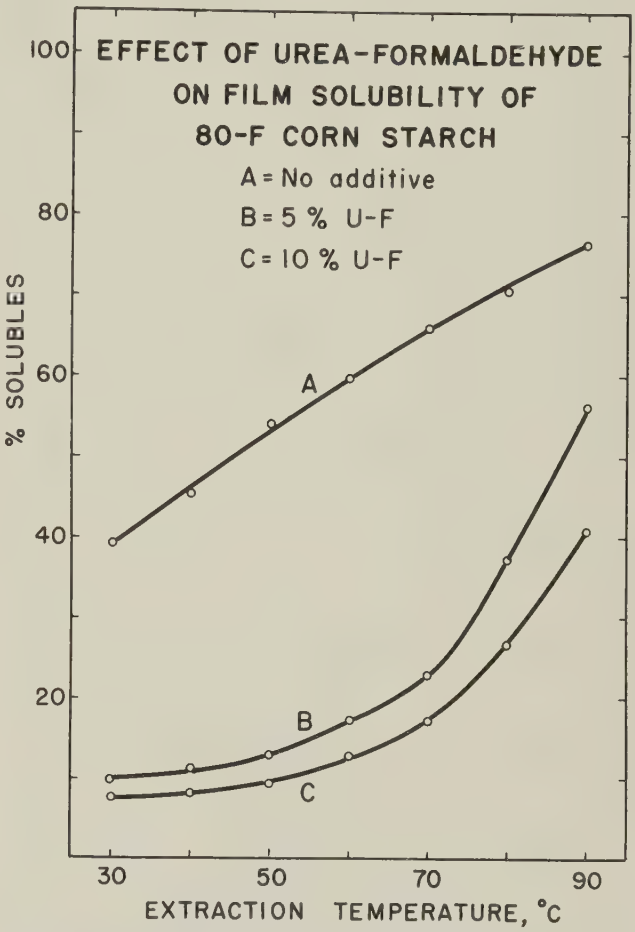

Fig. 9. Effect of urea-formaldehyde on the film solubility of 80-fluidity corn starch: (A) no U-F added, (B) 5% U-F added, and (C) 10% U-F added. All films dried at 80°C.

cooked in normal fashion, 5% of the urea-formaldehyde concentrate added (calculated on starch basis), and the film cast and dried in the circulating air oven at 80°C. Film solubilities were determined gravimetrically, since the presence of the urea-formaldehyde interfered with the anthrone colorimetric analysis. Figure 9 shows the very substantial reduction of solubles caused by chemical cross-bonding within the film, presumably occurring during oven-drying. Doubling the amount of urea-formaldehyde (i.e., 10% on starch basis) decreased the solubles even further. This technique appears to have usefulness for evaluating the insolubility imparted to starch films by copolymerization with various agents, e.g., the urea-formaldehyde-starch adhesives used in fabricating water-resistant corrugated board.

The solubility pattern of a mildly converted corn white dextrin is shown in Fig. 10. This product exhibits none of the irreversible association of the parent corn starch, being completely water soluble at 90°C. In this respect, it likewise differs from the

80-fluidity thin-boiling corn starch, which is only 77% soluble at 90°C. However, the white dextrin still shows evidence of "staling" of the branched starch fraction, since the film dried at room temperature is substantially less soluble at 30 to 40°C. than the oven-

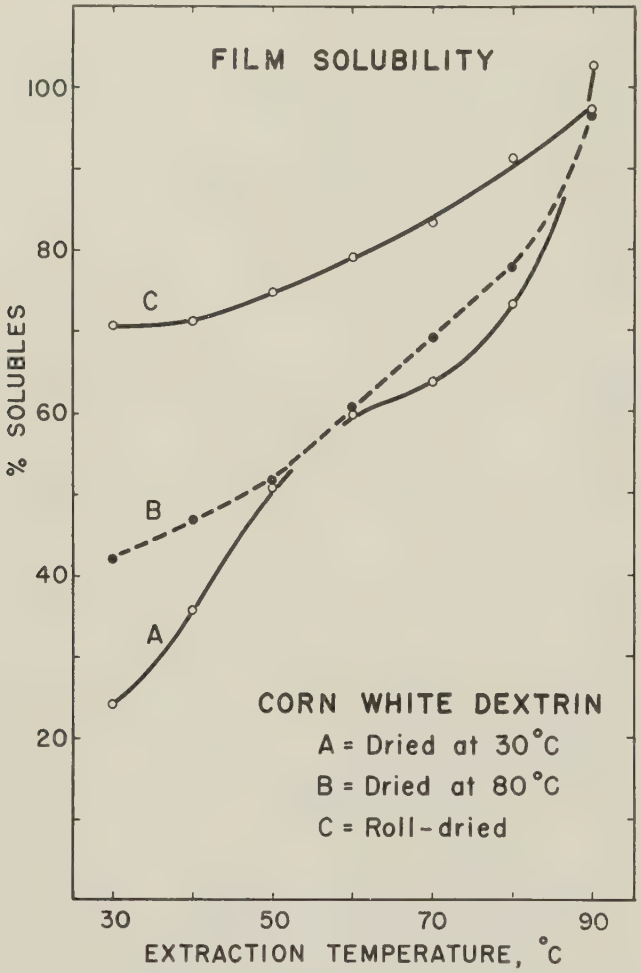

Fig. 10. Film solubility of corn white dextrin, (A) dried at 30°C., (B) dried at 80°C., and (C) roll dried

dried film. For purposes of manufacturing and sales specifications, the various starch gums and dextrins are frequently classified according to their solubility in cold water. While this test is highly useful for routine control on production, it has little correlation with either the solubility of the product in hot water, or the solubility of the final film. Thus, the white dextrin herein described had an original cold-water solubility of only 4.7%, due to associative bonding still persisting within the dextrinized granules. However, the internal structure has obviously been greatly weakened, so that the product dissociates and dissolves in hot water.

The properties of potato starch are radically different from those of corn starch. As one contributing factor, it contains only 20% of linear fraction, as compared with 28% in corn starch. In addition, the potato linear fraction is much less prone to retrograde and gel, due to some obscure difference in molecular structure which is not yet understood. Hence potato starch yields highly soluble films, as shown in Fig. 11. Indeed, the potato starch film dried at 80°C. is completely soluble at all extraction temperatures; the film dried at room temperature shows a considerable degree of weak association (i.e., "staling") at extraction temperatures below 60°C.

Sair and Fetzer (*10*) have shown that the character of potato starch may be drastically altered by heating the granular starch for an extended period of time at high humidity levels. According to their procedure, the starch was preadjusted to a moisture level of 20 to 25%, then heated at 100°C. for several hours in closed tubes. Microscopic examination showed no alteration in granule appearance or optical birefringence of the treated starch. However, they observed that this heat-moisture treatment changed the x-ray diffraction spectrum of the potato starch from its normal B-pattern to an A-pattern similar to that of corn starch, indicating an extensive alteration of the crystalline organization within the granule. In addition, the treated starch gave "short" relatively opaque pastes which set up to rigid gels on cooling, very similar to the behavior of corn starch. The present studies have disclosed a more convenient method of heat-moisture treatment, by suspending the granular starch in 70 to 72% (by

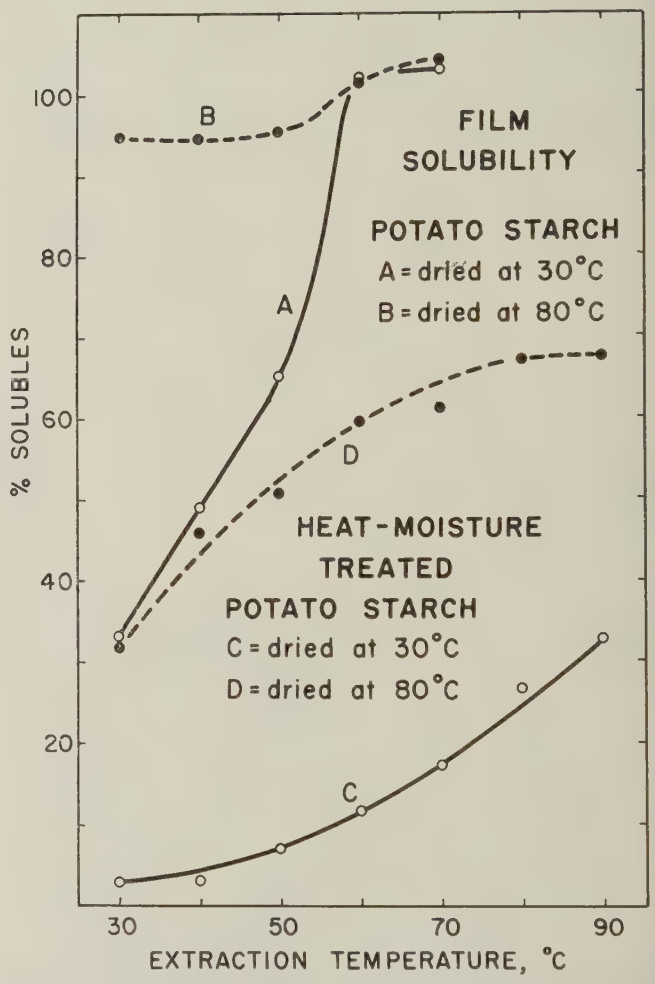

Fig. 11. Film solubility of unmodified potato starch, (A) dried at 30°C., and (B) dried at 80°C. Also, film solubility of heat-moisture treated potato starch, (C) dried at 30°C., and (D) dried at 80°C.

weight) diacetone alcohol, and heating the slurry under gentle reflux for 2 to 3 hr. This medium contains sufficient water to permit reorientation of the molecules within the granule, but without causing gelatinization of the starch. The Kofler gelatinization temperature of the treated starch is raised some 5 to 10°C., and the

granules show inhibited swelling rather than the free and unrestricted swelling of normal potato starch. Films prepared from this treated starch exhibit a much greater degree of association than the original potato starch (Fig. 11). Hence it appears that heat-moisture treatment increases the associative bonding within the granule, not only insolubilizing the linear fraction but likewise entangling the branched fraction. These effects persist through the cooking operation and are reflected in the final films. Films from normal potato starch may likewise be heat-moisture treated by refluxing in 70% diacetone alcohol; the solubility is significantly decreased, but the effect is much less pronounced than with films prepared from potato starch which has been heat-moisture treated in the granular state. Thus, the character of the final film is influenced not only by the content and structure of the linear fraction of the starch, but likewise by the nature of the physical organization which exists within the original starch granule.

It was of interest to ascertain whether aging of the

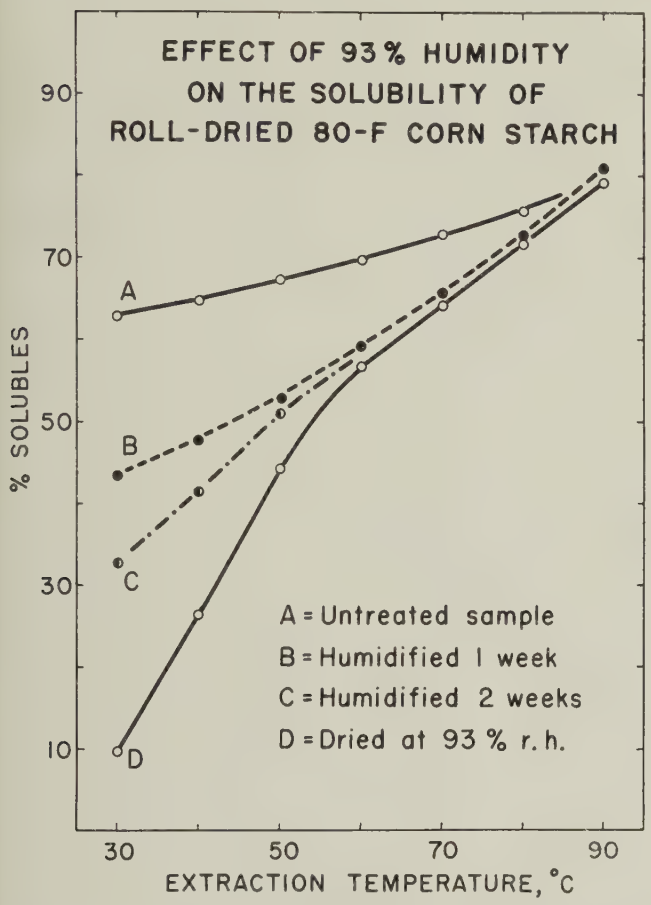

Fig. 12. Reduction of film solubility by humidity treatment of roll-dried 80-fluidity corn starch: (A) untreated roll-dried 80-fluidity starch, (B) after exposure for 1 week at 93% R.H., (C) after humidification for 2 weeks. Also (D) solubility of film of 80-fluidity starch slowly dried at 93% R.H.

starch paste prior to film casting had any effect on the solubility pattern of the final film. Accordingly, a 25% cooked paste of 80-fluidity corn starch was prepared, a few drops of phenyl mercuric acetate solution added as preservative, and the paste then divided into three parts. One portion of the hot paste was plated out as a film in the usual manner, drying at 80°C. and at room temperature. A second portion was allowed to age at room temperature for three days, then cast as a film. The final portion was similarly aged three days, then recooked and cast as a film. The resulting three pairs of films showed substantially the same solubility patterns as depicted in Fig. 4, and any differences appeared to be within experimental error. Hence it appears that age of the paste does not materially alter the character of the resulting film, providing no bacterial degradation has occurred.

Starch films containing 8 to 12% moisture have been stored at room temperature for a year or more without any significant change in their solubility patterns. However, films exposed to very high humidities show a decrease in solubility, presumably because the high moisture content permits a slow molecular orientation into a more associated pattern. To illustrate this effect, a cooked paste of 80-fluidity corn starch (containing a trace of phenyl mercuric acetate) was dried on heated squeeze rolls. The product had an initial solubility pattern shown in Fig. 12. Samples of this roll-dried starch were stored at 30°C. and a relative humidity of 93% for 1 and 2 weeks, which resulted in a progressive decrease in film solubility. As an extreme instance of insolubilization, the original cooked paste of this starch was coated out on stainless steel plates and allowed to dry very slowly at 30°C. and a relative humidity of 93%. All four curves converge at an extraction temperature of 90°C. Hence, it seems probable that the association produced by humidification is largely due to staling of the branched starch fraction.

These investigations have been concerned primarily with the fundamental physical properties of starch films, in order to delineate certain basic principles which may influence the behavior of starch over a wide variety of uses. Thus it is presumed that a remoistening gum should give a molecularly-dissociated and readily soluble film. Conversely, a high degree of association may assist the wet-rub resistance of a paper coating and improve the "crispness" of a starch-sized sheet at higher humidities. Further studies are currently under way to relate film association to such practical factors as wet-rub resistance of clay coatings, the flexibility of films as affected by humidity, and strength of adhesive bonding (e.g., in corrugated board).

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Lignin from the Alkaline Hydrogenation of Sugar Maplewood

*II. The Acidic and Water Soluble Fractions**

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Six acids have been isolated from the lignin fraction obtained on alkaline hydrogenation of sugar maplewood, and have been identified as *p*-hydroxybenzoic, vanillic, syringic, guaiacylacetic, guaiacylpropionic, and syringylpropionic acids. Evidence is also presented that catechol or pyrogallol derivatives may be present in the liquor. These presumably would be formed by demethylation of guaiacol or syringyl residues.

It is possible to remove lignin from hardwood by cooking with sodium hydroxide solutions. If a *simultaneous* catalytic hydrogenation is carried out upon the pulping liquors, the reactive intermediates from lignin degradation are hydrogenated to stable molecules before they can repolymerize to the amorphous brown materials known as soda lignin. Instead on isolation from the cooling liquors, the lignin is found to be primarily a mixture of three distillable monomeric phenols and low molecular weight thermoplastic resins (*1–7*). A research has been initiated at this college and supported by TAPPI with the objective of identifying other components of this mixture, in the belief that some are dimeric and should give an insight into the structural features linking monomeric units together in lignin.

The ether and chloroform-soluble lignin from an alkaline hydrogenation pulping of maplewood was subjected to a countercurrent distribution between sodium phosphate buffer and butanol. Four major fractions were obtained. Two were shown to consist largely of the three monomeric phenols isolated by Pepper and Hibbert, the third major fraction was shown to contain two additional monomers: 3-(4-hydroxy-3,5-dimethoxy phenyl) - 1 - propanol and 3 - (4 - hydroxy - 3 - methoxyphenyl)-1-propanol (*5*).

The fourth major fraction obtained on countercurrent distribution of ether and chloroform-soluble lignin was that portion of the material preferentially soluble in sodium phosphate and which remained in the first 15 tubes of a countercurrent distribution apparatus after 100 transfers against butanol. On countercurrent extraction over 190 transfers (Fig. 6 (*5*); reported incorrectly as 100 transfers), this fraction was previously divided into a number of smaller well-defined peaks, the composition of which has now been studied in the following fashion.

Since it appeared that these compounds might be acidic, the chloroform solution of hydrogenated lignin obtained by extracting the acidified pulping liquor was re-extracted with sodium bicarbonate to obtain an acidic fraction. This was subjected to paper chromatography. The developers (I and VII) were chosen from seven tested for the separation of six phenolic acids: syringic, vanillic, *p*-hydroxybenzoic, guaiacylacetic, guaiacylpropionic, and syringylpropionic. Two diazonium salts were used as indicators (Table I) (*8*).

An initial separation of the acidic fraction on Whatman seed test paper gave seven bands (Table II) of which the three having R_f values higher than 0.50 were not further investigated. Those having high R_f values have little chance of resolution and most probably consist in any case of the monomeric phenols investigated previously (*9*). The four bands having lower R_f values were cut out and extracted. The concentrated extracts of the four bands were rechromatographed individually on Whatman no. 1 paper using developer no. 7 and were separated into pure compounds. Six were identified as the acidic compounds mentioned previously and shown in Tables II and III. Their identification rests on the similarity of R_f values of the acids from the hydrogenation with known synthetic samples in two solvent systems, their color on coupling with diazotized sulphanilic acid, and the character of their ultraviolet absorption spectra. The ultraviolet spectra of the unknown acids were identical with the spectra of known samples in the positions of maxima and minima, but the extinction coefficients could not be determined since it was not practical to determine the amount of isolated compound present by weight. However, when the maxima of the curves of unknown and known samples were adjusted to be identical in absorbance, the same adjustment made the entire spectrum of each unknown acid essentially superposable on the corresponding known. This was true of all spectra in both neutral and alkaline solution. It was then possible to calculate the per cent of the lignin recovered as each of these acids from the extinction coefficients of the knowns.

In addition, two unknown substances (AII and CIV) were isolated with spectra more similar to simple phenols. In view of the small quantities present they were not investigated in detail.

The distribution coefficients of these acids between butanol and 1.1 molal phosphate buffer were determined and their position in a 190 tube transfer calculated (Table IV). This was compared with the results obtained by Arlt on his fraction F-10 (Fig. 6 (*5*)). In three cases, definite peaks are noted at positions quite close to the calculated values and probably correspond

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Table I. Chromatography of Phenolic Acids

Developer[a]	R_f values					
	Syringic	*Vanillic*	*p-Hydroxybenzoic*	*Guaiacylacetic*	*Guaiacylpropionic*	*Syringylpropionic*
1	0.21	0.25	0.30	0.28	0.47	0.28
2	0.10	0.07	0.11	0.12	0.11	0.12
3	0.09	0.06	0.12	0.12	0.09	0.09
4	0.08	0.12	0.18	0.13	0.11	0.13
5	0.15	0.15	0.15	0.23	0.22	0.21
6	0.72	0.74	0.32	0.55	0.78	0.45
7	0.45	0.52	0.12	0.36	0.83	0.30
Indicator						
DPNA[b]	Dark blue	Violet	Orange	Gray blue	Gray blue	Gray blue
DSA[c]	Crimson	Brownish-orange	Yellow	Brownish-red	Pink	Pinkish blue

[a] The developers were (1) *n*-propanol-conc. ammonia-water (20:4:1); (2) *n*-butanol-conc. ammonia (5:1); (3) *n*-butanol-phosphate buffer, pH 12 (saturated, organic layer); (4) *n*-butanol-2% ammonia (saturated, organic layer); (5) *n*-butanol-water (saturated, organic layer), paper soaked in phosphate buffer, pH 12; (6) benzene–80% acetic acid (saturated, organic layer); (7) benzene–90% formic acid (saturated, organic layer).
[b] Diazotized *p*-nitroaniline.
[c] Diazotized sulphanilic acid.

to the identified compound, and in three cases the presence of the acids in Arlt's distribution pattern is masked by other substances. No compound corresponding to a fairly substantial peak observed by Arlt in tube 19 was identified in the present work.

The presence of small amounts of phenolic acids among the products of alkaline hydrogenation is not surprising since alkaline hydrolysis alone has been reported to yield several phenolic acids from hardwoods. Pearl (*10*) found syringic, vanillic, and ferulic acids in the alkaline hydrolysis liquors of sugar maple. Smith (*11*) reported *p*-hydroxybenzoic acid in the alkaline extracts of European aspen. Pearl (*12*) found the same acid in alkaline extracts of American aspen woodmeal which had been thoroughly extracted with benzene-ethanol. Stanek (*13*) also noted that *p*-hydroxybenzoic acid could be obtained in increasing amounts by successive hydrolyses of aspen woodmeal. The presence of guaiacylacetic acid and syringylpropionic seems to be hitherto unreported.

This work now brings to 12 the total number of identified compounds from the alkaline hydrogenation of hardwood.

We have also made some observations on a water-soluble lignin fraction. In previous research in this series it was difficult to account for more than about 85 or 90% of the lignin even if allowance was made for probable loss of small fragments of the structure by hydrogenolysis or alkaline cleavage. Previous investigations were carried out on the lignin extracted from acidified liquors by chloroform. If, however, the aqueous liquors are next saturated with salt and extracted with butanol, a second lignin fraction essentially free of carbohydrates is obtained, which probably accounts for the missing portion of the lignin.

Table II. Two-Step Chromatography of Acidic Fraction from Hydrogenation

Total fraction on seed test paper, developer 1			*Individual bands on whatman no. 1, developer 7*			
Band	R_f *value*	*Color, DPNA*	*Band*	R_f *value*	*Color, DSA*	*Identification*
A	0.22	Dark blue	A I	0.44	Crimson	Syringic
			A II	0.65	Pink	...
B	0.25	Violet	B I	0.44	Crimson	Syringic
			B II	0.52	Orange	Vanillic
C	0.31	Brown	C I	0.12	Yellow	*p*-Hydroxybenzoic
			C II	0.30	Pink-blue	Syringylpropionic
			C III	0.36	Pink	Guaiacylacetic
			C IV	0.91	Pink	...
D	0.48	Dark blue	D I	0.83	Pink	Guaiacylpropionic
E	0.56	Dark blue				
F	0.81	Dark blue				
G	0.86	Dark blue				

This material has a maximum absorption at 276 mmu and a minimum at 260 mmu.

Paper chromatography, the method of choice for the separation of water-soluble substances, failed because of the tendency of the material to decompose (apparently by oxidation) on the paper. After a few hours, no spots were visible with spray reagents. The materials also were not recoverable from alumina. Furthermore if the aqueous alkaline liquors were removed from the pulp in the absence of air, they were found to be quite light in color, but as air reached the liquors they darkened at the surface. This presumably is evidence of catechol or pyrogallol derivatives which may be derived by demethylation of guaiacyl and syringyl type compounds. Presumably these were present in the butanol-soluble fraction, but the addition of boric acid and sodium acetate to aqueous solutions of the phenols did not result in a change in spectrum (*14*).

EXPERIMENTAL

Preparation of Model Phenolic Acids

I. *Guaiacylacetic Acid* (Homovanillic Acid). A Willgerodt reaction of acetovanillone with sulphur and morpholine gave the morpholide of thiohomovanillic acid which on alkaline hydrolysis and subsequent acidification gave homovanillic acid (*5*). Yellowish-white shiny plates, m.p. 140–141°C.

II. *Guaiacylpropionic Acid.* Ferulic acid was prepared through condensation of malonic acid with vanillin and subsequent decarboxylation. This was hydrogenerated to give guaiacylpropionic acid (*15*). Colorless prisms, m.p. 84–85°C.

Table III. Spectral Data and Percentage of Isolated Compounds

Band	*Compound*	*Wave length maximum, mmu*					*Recovery of Klason lignin, %*
		Neutral	*Alkaline*	*Difference*	E^a	E^b	
A I	Syringic	274	301	305	52	63	0.14
B I							
A II	Unidentified	280	283	300	...	...	...
B II	Vanillic	293	298	303	35.5	65.5	0 05
		258					
C I	*p*-Hydroxybenzoic	253	278	286	106	116	0.02
C II	Syringylpropionic	272	287	298	6.5	19.5	0.17
			251				
C III	Guaiacylacetic	281	296	298	13.5	19	0.12
C IV	Unidentified	286	286	286	...	...	...
D I	Guaiacylpropionic	275	297	298	8.75	13.5	0.14
			245				

[a] Extinction in liter per gram centimeter at absorption maximum in neutral medium. Reference compounds only.
[b] Extinction in liter per gram centimeter at maxima of difference spectra. Reference compound only.

III. *Preparation of Syringyl Propionic Acid.* This was prepared exactly as above from syringaldehyde via sinapic acid. Colorless needles, m.p. 102–103°C.

Syringic, vanillic, and *p*-hydroxybenzoic acids were available.

Paper Chromatography of Model Acids

Several solvent systems for the development of these acids on paper sheets were employed initially to select the ones good for separation of these acids. The developed chromatograms of individual acids placed separately on one sheet were sprayed with diazotized sulphanilic acid or diazotized *p*-nitroaniline. Characteristic colors developed almost immediately (Table I).

Preparation of Hydrol Lignin and Acidic Fraction

Extractive-free sugar maple woodmeal was hydrogenated in 6% NaOH solution in the presence of Raney nickel at a temperature of 165 ± 5° for 3 hr. Initial pressure was 700 p.s.i.g. After filtration and acidification, the liquor was thoroughly extracted with chloroform ethanol (2:1). After concentration to a small volume, the solution was poured slowly into anhydrous ether. The precipitate formed was filtered off. Solvent was evaporated from the filtrate, the residue was redissolved in chloroform and extracted with dilute sodium bicarbonate solution. The bicarbonate extract was acidified and extracted again with chloroform. This represented the material used for this analysis and represented 2.0% of Klason lignin.

Fractionation of Acids on Whatman 3MM

A preliminary chromatography of the bicarbonate-soluble fraction on Whatman no. 1 paper using developer 1 in descending direction showed that this fraction still contained considerable amount of material running faster than the fastest moving acid (R_f 0.47).

Two hundred milligrams of bicarbonate-soluble fraction was applied as a streak on Whatman 3 MM. The paper was developed in solvent no. 1 in ascending direction. After developing for 18 hr, the paper was dried. Thin strips were cut off from both sides perpendicular to the base line and sprayed with diazotized *p*-nitroaniline. After the spots were revealed, R_f values and color were noted. The strips were laid on respective sides of the paper, base lines were matched, and lines touching the front and back edges of similar spots on the strips were drawn on the main paper. Seven bands were obtained. The bands having R_f values greater than 0.5 were not further investigated. Others were cut out and extracted with 95% ethanol in Soxhlet extractors for 3 hr. The extracts were concentrated and applied as streaks on separate sheets (57 by 47 ch.) of Whatman no. 1 paper. Reference acids were also spotted on both sides of the paper, which was developed in benzene-formic acid (developer 7) for 8 hr. Strips cut from both sides were sprayed with diazotized sulphanilic acid.

The bands on the paper were located and cut off as before. The paper strips were extracted in small Soxhlet extractors with ethanol for 3 hr. The extracts were concentrated to small volume under reduced pressure and made up to 50 ml. These solutions were diluted with an equal volume of 95% ethanol or of a 0.4% sodium hydroxide ethanolic solution. Spectra were determined in a Beckman Model-DU spectrophotometer. Results are reported in Table II and Table III.

Table IV. Distribution of Acids Between Phosphate Buffer and Butanol

Acids	*Distribution coefficient*	*Tube no.* — *Calculated*	*Tube no.* — *Observed (5)*
Syringic	0.066	12	11
Vanillic	0.026	5	Masked by background
p-Hydroxybenzoic	0.253	38	37
Guaiacylacetic	0.162	26	23
Guaiacylpropionic	0.384	51	Masked by phenols in A
Syringylpropionic	0.330	47	Masked by phenols in A

Calculation of Tube Number in Craig Machine

n-Butanol was equilibrated with a phosphate buffer solution which was 0.4 *M* in trisodium phosphate and 0.7 *M* in tripotassium phosphate. The separated layers were stored in separate well-stoppered bottles. Ten milliliters of each phase were pipetted into a separatory funnel and a known amount (100 microg.) of the acid was introduced into the mixture. After shaking well, the phases were allowed to separate. The top layer was collected and acidified with 1 ml. of 4 *N* HCl. The absorbance of the solution at 280 mmu was recorded. The absorbance of the total amount of acid in same volume of top layer similarly acidified was also determined. From these data, concentration of the acid in both phases and the distribution coefficients were calculated (*16*).

The tube N in which the maximum concentration of a particular acid is likely to be found in a Craig machine involving 190 transfers and using the above solvent system was calculated from the following formula (*16*). Results are in Table IV.

$$N = nKr/(Kr + 1)$$

where

n = total number of transfers.
r = ratio volumes.
K = distribution between upper and lower layers.

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Drainage on the Fourdrinier Table Roll Section

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In a previous investigation, the calculation of wet pulp mat filtration resistance from table roll drainage data was discussed and compared to laboratory-measured values. In actual practice, however, the reverse procedure would be most commonly followed, that is, to predict drainage of the table roll section from a laboratory determination on pulp filtration resistance. This investigation presents the results for predicted drainage for two commercial machines and compares them with the actually observed values. Samples of stock from the couch roll of a bond paper machine operating at 343 f.p.m. and another machine using a board furnish at 243 f.p.m. were analyzed in the laboratory for pulp filtration resistance with and without fines present. From these data and from an estimate of the paper machine wire resistance, it was possible to predict the relationship between total filtration resistance and mat basis weight. This information was used with the Taylor theory of drainage to calculate the wire length required to form a mat of given basis weight. The results compared favorably with the actual machine wire lengths for the specified operating conditions. A rigorous solution of the drainage equations involves rather tedious trial-and-error calculations and therefore an approximate solution is presented and discussed. The results indicate the methods are accurate and demonstrate the practicality of predicting drainage on the paper machine from the results of laboratory experiments alone. However, because of a lack of fundamental knowledge concerning the rheology of the wet mat, the effects of fiber flocculation on mat structure, and the effects of incomplete retention on filtration resistance, it is necessary to use empirical factors to account for these effects.

In a previous paper (*1*), filtration resistance over the table rolls was calculated from paper machine drainage data and then compared to laboratory-measured values of filtration resistance. The utility of the quantitative drainage relationships will depend upon the reverse procedure of using laboratory measurements to predict machine drainage for specified operating conditions. The analysis of the data from the previous investigation (*1*) provides a basis for predicting filtration resistance on the table roll section from laboratory measurements and with a minimum amount of empirical factors.

The purpose of this paper is (1) to develop a method for the analysis of laboratory data leading to the prediction of filtration conditions on the paper machine, (2) to test the validity of the proposed method of analysis by checking the predicted results against known paper machine performance, (3) to simplify the relationships between laboratory and machine variables to provide working equations, and (4) to illustrate some of the possible uses of the drainage equations. It should be emphasized that the treatment used in this paper does not increase understanding of the mechanisms of water removal on the paper machine wire. As previously pointed out (*1*), increased understanding will depend upon the development of fundamental knowledge concerning the rheology of the wet mat, relative contributions of fibers and fines to flow resistance, and orientation and flocculation effects on flow phenomena. Because of lack of information in these areas, the approach taken in this paper is to use empirical factors to account for the little-understood effects.

Data obtained from two different fourdrinier paper machines were used to test the validity of the proposed analysis: first, the previously obtained data (*1*) from a machine producing bond paper at 343 f. p. m., and second, new data from a machine operating at 243 f. p. m. on a board furnish. These two separate cases are distinguished in further discussion by referring to them as "bond furnish" and "board furnish."

METHOD OF ANALYSIS

In the previous comparison between laboratory measurements and machine measurements of filtration resistance, the following hypothesis for sheet formation was advanced. As stock is deposited on the wire at the breast roll, drainage with accompanying mat formation begins. The first layer of mat that is formed consists mainly of fibers, since essentially all the fines in the stock will pass through the wire at this point. As drainage continues at subsequent table rolls, the mat thickness will gradually increase as the level of stock on the wire decreases. As the mat thickness increases, the retention of fines in the mat increases and the white water consistency decreases. It was suggested that the main increase in specific filtration resistance was because of the greater amount of fines retained in the mat structure.

The driving force causing drainage at the table roll nip was studied by Taylor (*2*) and Wrist (*3*), who showed that the suction developed by table roll action increases from zero to a maximum value proportional to the square of machine speed, and then decreases to zero at the end of the nip. Because of the compressible nature of a wet cellulosic mat, the fluid drag forces during drainage at the nip will tend to compress the mat. The results of the previous study indicated that because of the viscoelastic character of the wet mat and the relatively short duration of suction pulse, the mat is compacted by only a small fraction of the maximum pressure drop across it.

The total filtration resistance at any point on the wire is the sum of the resistance of the wire and the resistance of the mat at that point. The rate of change of total resistance with respect to the average basis weight at a table roll is defined as the specific filtration resistance.

$$\frac{dR_t}{d(W_n)_{av}} = R \qquad (1)$$

By measuring the slopes of the curve relating total

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NOMENCLATURE

a	=	table roll radius, centimeters.
K	=	grouping of machine variables defined by equation (10), grams per (centimeters)^4.
k_1	=	constant related to filtration resistance by equation (5), cubic (centimeters) per sq. gram.
k_2	=	constant related to filtration resistance by equation (4), centimeters per gram.
L	=	width of fourdrinier wire, centimeters.
m	=	ratio of mass of wet mat to mass of dry mat, dimensionless.
N	=	total number of table rolls.
n	=	table roll number.
ΔP	=	pressure drop, dynes per square centimeter.
ΔP_e	=	effective compacting pressure acting on mat, dynes per square centimeter.
Q	=	total drainage from table roll section, cubic centimeters per second.
q_n	=	volumetric rate of drainage from nth table roll, cubic centimeters per second.
R	=	average specific filtration resistance of mat, centimeters per gram.
R_0	=	average specific filtration resistance of mat formed at breast roll, centimeters per gram.
R_t	=	total filtration resistance of mat and wire (centimeters)$^{-1}$.
R_w	=	average specific filtration resistance of mat formed at end of table rolls, centimeters per gram.
s	=	consistency of slurry on wire, grams of solids per gram of slurry.
U	=	wire velocity, centimeters per second.
W_n	=	mat basis weight leaving table roll n, grams per square centimeter.
ΔW_n	=	basis weight of solids deposited in mat at nth table roll, grams per square centimeter.
$(W_n)_{av}$	=	arithmetic average of mat basis weight entering and leaving nip area at nth table roll, grams per square centimeter.
w_n	=	consistency of white water draining from nth table roll, grams of solids per gram of white water.
α	=	wire resistance to flow, (centimeters)$^{-1}$.
μ	=	white water viscosity, poises.
ρ	=	white water density, grams per cubic centimeter.

filtration resistance, R_t, to the arithmetic average basis weight, $(W_n)_{av}$, at table roll n, the specific filtration resistance, R, was determined in the previous study (*1*) from paper machine data. The experimentally measured values for the specific filtration resistance of the bond furnish is related to the basis weight in Fig. 1. The relationship is a linear one of the following form:

$$\frac{dR_t}{d(W_n)_{av}} = 2k_1(W_n)_{av} + k_2 \qquad (2)$$

where k_1 and k_2 are constants. The relationship between the total filtration resistance and the average basis weight may be determined by integrating equation (2) to give

$$R_t = k_1(W_n)_{av}^2 + k_2(W_n)_{av} + \alpha \qquad (3)$$

where α is the wire resistance. This relationship is parabolic in nature, and it was previously noted (*1*) that a similar relationship was observed by Wrist (*4*) for a newsprint furnish at 680 f. p. m.

The problem is to estimate the constants, k_1, k_2, and α, from laboratory measurements. The effective wire resistance, α, is higher than the resistance which can be measured for a bare wire because of the interaction between fibers and wire. Presently, no extensive data are available for effective wire resistances. Therefore, the previously determined (*1*) experimental value for a 70 × 56-mesh twill wire of 1.08×10^5 cm.$^{-1}$ will be used. The constants, k_1 and k_2, may be determined from laboratory measurements of specific filtration resistance. This is done using equation (2). When the basis weight is zero, equation (2) becomes

$$k_2 = R_0 \qquad (4)$$

where R_0 is the specific filtration resistance of stock from which all fines have been removed. This resistance would correspond to that of the first layer formed at the breast roll where fines are not retained. At the end of the table roll section when the mat presumably would be completely formed, the basis weight is W and equation (2) becomes

$$k_1 = \frac{R_w - R_0}{2W} \qquad (5)$$

where R_w is the specific filtration resistance of stock at the end of the table roll section. This stock can be approximated by a couch roll sample or by a sample of stock going to the head box, provided the white water system is essentially closed.

The total filtration resistance, R_t, at the nth table roll may be related to the basis weight formed at that roll by combining Taylor's (*2*) drainage equation and the equation derived by a material balance (*1*) over a table roll. Taylor's equation is

$$q_n = \frac{0.590\rho^2 a U^3 L}{2\mu^2 R_t^2} \qquad (6)$$

where ρ and μ are white water density and viscosity, respectively, a is the table roll radius, U and L are the wire speed and wire width, respectively, and q_n is the volumetric drainage rate at the nth table roll. The material balance equation is

$$\Delta W_n = \left[\frac{s - w_n}{1 - sm}\right] \frac{\rho q_n}{UL} \qquad (7)$$

where ΔW_n is the mat basis weight deposited at the nth roll, s and w_n are the consistencies of slurry on the wire and the white water, respectively, and m is the moisture content of the mat formed on the wire. Substituting for q_n from equation (6) in equation (7) gives

$$\Delta W_n = \frac{0.590\rho^3 a U^2}{2\mu^2 R_t^2} \left[\frac{s - w_n}{1 - ms}\right] \qquad (8)$$

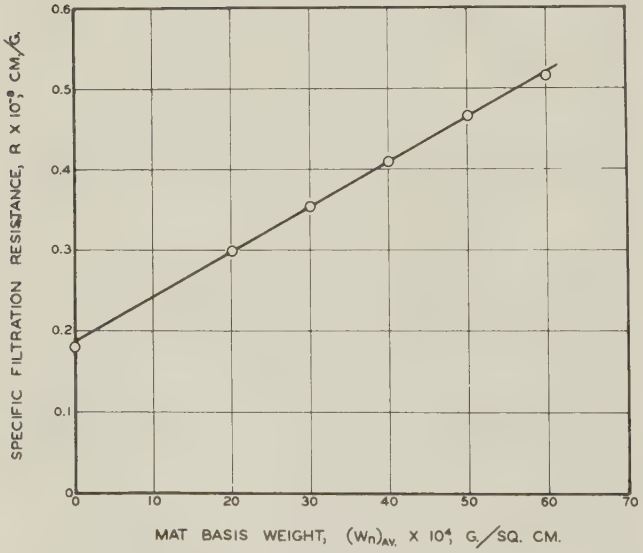

Fig. 1. Specific filtration resistance as a function of mat basis weight for bond furnish

Laboratory measurements of specific filtration resistance are used to calculate the relationship between total filtration resistance and basis weight by using

Table I. Paper Machine Operation

	Machine 1— bond furnish	*Machine 2— board furnish*
Wire speed, U, cm./sec.	174	123.5
Number of table rolls, n	39	37
Table roll radius, a, cm.	5.72	8.10
Headbox consistency, s, g./g.	0.00555	0.0121
White water consistency, w, g./g.	0.00119	0.00112
White water viscosity, μ poise	0.00762 (90°F.)	0.00762 (90°F.)
Basis weight, W, g./sq. cm.	0.00591	0.0211

equation (3). Then, the paper machine variables are related to this curve by using equation (8).

EXPERIMENTAL DATA

The operating conditions for the paper machine producing bond furnish and board furnish are shown in Table I. These data are readily obtained for any paper machine.

The filter mat moisture contents, m, were determined for the bond and board stocks by measuring the apparent mat density under fluid stress in a laboratory filtration tube (*1*, *5*). These data are correlated as a function of pressure drop in Fig. 2. Over a limited pressure range, m is an exponential function of ΔP which is rectified on logarithmic co-ordinates. The moisture content depends upon the mat compressibility and upon the hydrodynamic specific volume of the fibers.

The specific filtration resistances of the stocks were measured at 0.01% consistencies with a constant-rate filtration technique (*5*, *6*). Couch roll samples were used, and one set had fines removed by classifying in a Bauer-McNett apparatus and discarding the material passing through a 150-mesh screen. The pulp specific filtration resistances are correlated in Fig. 3, where it may be seen that specific filtration resistance is a linear function of pressure drop on logarithmic co-ordinates. This linearity is only approximate over a limited range of pressure. Pulp filtration resistance depends upon fiber specific surface, specific volume, and mat compressibility.

At consistencies in appreciable excess of the 0.01% used in the laboratory, fiber suspensions are flocculated and the filtration resistance will be decreased as much as 20 to 35% (*1*, *5*). Although no extensive flocculation data are available, data from previous studies using a figure of 1.35 for the ratio of specific filtration

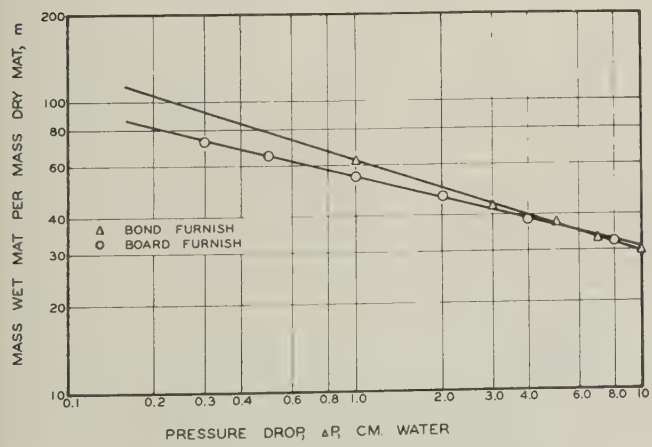

Fig. 2. Filter mat moisture content

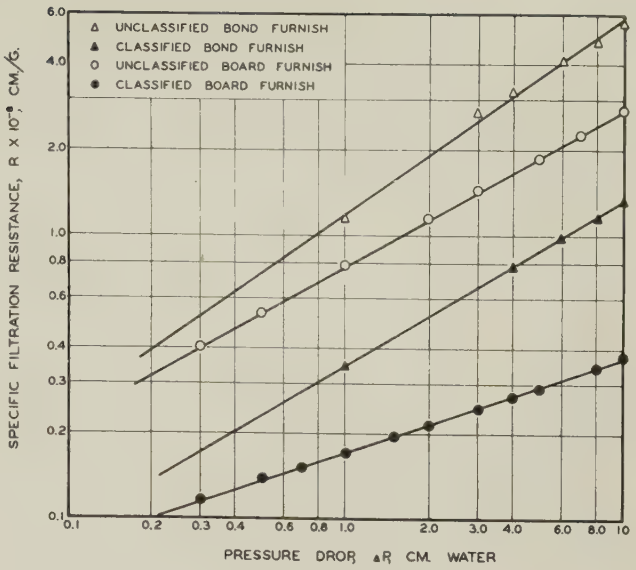

Fig. 3. Effect of pressure drop of laboratory-measured specific filtration resistance

resistance at 0.01% to filtration resistance at 0.5 to 1.0% will be used here.

RESULTS AND DISCUSSION

The first step in the calculation of paper machine filtration resistance is to estimate the effective compacting pressure across the mat. This pressure drop was previously estimated to be $^1/_{20}$ of the maximum pressure drop across the mat (*1*). It might be expected that this factor would depend upon machine speed, but in this study the $^1/_{20}$ figure will be used. Considering first the bond furnish machine, the maximum pressure drop across *both* mat and wire is given by $(^1/_2)\ \rho U^2$, which is equal to 15.5 cm. of water at a wire speed of 343 f. p. m. As a first approximation, it is assumed that the effective pressure drop across the mat is $(^1/_{20})$ (15.5) or 0.77 cm. water. The values of R_0 and R_w may be obtained by dividing the values at this pressure drop from Fig. 3 by the flocculation factor of 1.35. Assuming wire resistance, α, equal to 1.08×10^5 cm.$^{-1}$, and calculating k_1 and k_2 from equations (4) and (5), gives a total resistance, R_t of 3.92×10^5 cm.$^{-1}$ from equation (3) using the average basis weight of 59.1×10^{-4} g./sq. cm. at the end of the table roll section. Now, the effective pressure drop across the mat is estimated as $[(3.92 - 1.08)/3.92]\ 0.77$, which equals 0.56 cm. water. This value is used for a second trial calculation of k_1 and k^2, and R_t now equals 3.37×10^5 cm.$^{-1}$, which is equivalent to an effective pressure drop of $[(3.37 - 1.08)/3.37]\ 0.77 = 0.52$ cm. water. A third trial using 0.52 cm. water pressure drop across the mat gives R_t equal to 3.24×10^5 cm.$^{-1}$, which corresponds to an effective pressure drop of 0.51 cm. of water. This answer is within the precision of the calculation, and 0.51 cm. water is assumed to be the effective pressure drop across the mat. For an effective pressure drop of 0.51 cm. of water, from Fig. 3,

$$R_0 = (1/1.35)(0.233 \times 10^8) = 0.173 \times 10^8 = k_2,$$
$$R_w = (1/1.35)(0.750 \times 10^8) = 0.555 \times 10^8,$$

and from equation (5)

$$k_1 = \frac{(0.555 - 0.173) \times 10^8}{2 \times 59.1 \times 10^{-4}} = 32.3 \times 10^8$$

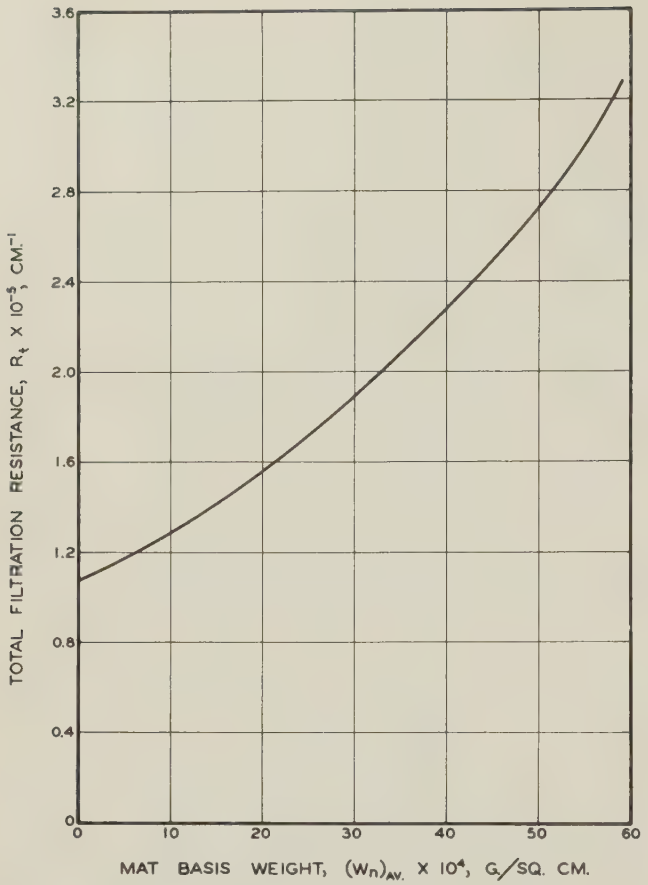

Fig. 4. Total filtration resistance at table rolls for bond furnish

and equation (3) becomes

$$R_t = 32.4 \times 10^8(W_n)_{av}^2 + 0.173 \times 10^8(W_n)_{av} + 1.08 \times 10^5$$

This equation, giving the increase in total filtration resistance as the basis weight increases along the table roll section, is shown in Fig. 4. This curve is related to paper machine variables by equation (8). For each incremental basis weight formed at a table roll, the arithmetic average basis weight, $(W_n)_{av}$, may be calculated, and related to total filtration resistance, R_t, with equation (8). Although the white water consistency, W_n, decreases along the table roll section, the average value given in Table I will be used for all the table rolls. The effect of calculating too small a basis weight near the breast roll by using the average white water consistency will be partially compensated by calculating too large a value near the end of the table roll section. In addition, the breast roll will be assumed to act as a table roll, and this will also tend to counterbalance the error involved in use of an average white water consistency.

Equation (8) may be written for the given operating conditions in Table I as

$$\Delta W_n = \frac{K}{R_t^2} \qquad (9)$$

where

$$K = \frac{0.590 p^3 a U^2 (s - w_{av})}{2\mu^2(1 - ms)} \qquad (10)$$

For the bond furnish, at an effective pressure drop previously calculated as 0.51 cm. water, $m = 77$ from Fig. 2, and $K = 6.72 \times 10^6$ g./cm.[4] Now, the calculation of the number of table rolls involves a trial-and-error calculation for each table roll, starting with the breast roll at $n = 0$. A value of R_t is assumed and ΔW_n is calculated from equation (9). Then, $(W_n)_{av} = \Delta W_{n=0}/2$, and the calculation is repeated until R_t and $(W_n)_{av}$ fall on the curve in Fig. 4. Next, for $n = 1$, a larger value of R_t is assumed and repeated until $(W_{n=1})_{av} = (\Delta W_{n=0} + \Delta W_{n=1})/2$ agrees with the value from Fig. 4. This procedure is repeated for each table roll until $(W_n)_{av} = W$, or 59.1 $\times$ 10^{-4} g./sq. cm. in Fig. 4, which corresponds to the end of the table roll section. The calculation using Fig. 4 for the bond furnish gives a total number of table rolls of 37. The actual number of rolls was 39, and this is considered as a reasonable check of the validity of the method of analysis.

Because equation (9) involves only conditions at a single table roll, the method of relating machine variables to the over-all table roll drainage conditions is extremely tedious and time-consuming. Furthermore, every change of machine conditions would involve a repetition of trial-and-error calculations for each table roll. What is desired is an equation relating the machine conditions to the over-all table roll drainage. R. Daane and S. T. Han of Beloit Iron Works suggested that the average basis weight could be treated as a continuous function of the table roll number so that

$$\frac{d(W_n)_{av}}{dn} = \Delta W_n \qquad (11)$$

S. T. Han integrated this equation by using equations (3) and (9) so that

$$K \int_0^N dn = \int_0^W [k_1(W_n)^2_{av} + k_2(W_n)_{av} + \alpha]^2 d(W_n)_{av} \qquad (12)$$

which gives

$$KN = \frac{k_1^2}{5} W^5 + \frac{k_1 k_2}{2} W^4 + \left(\frac{2k_1\alpha + k_2}{3}\right) W^3 + k_2\alpha W^2 + \alpha^2 W \qquad (13)$$

where N is the total number of table rolls.

This method is an approximation, but will give very nearly the correct answer provided the number of table rolls is relatively large. The limitations of the equation may be seen by considering Fig. 5 in which the reciprocal of the incremental basis weight, ΔW_n, is shown as a continuous function of the arithmetic average basis

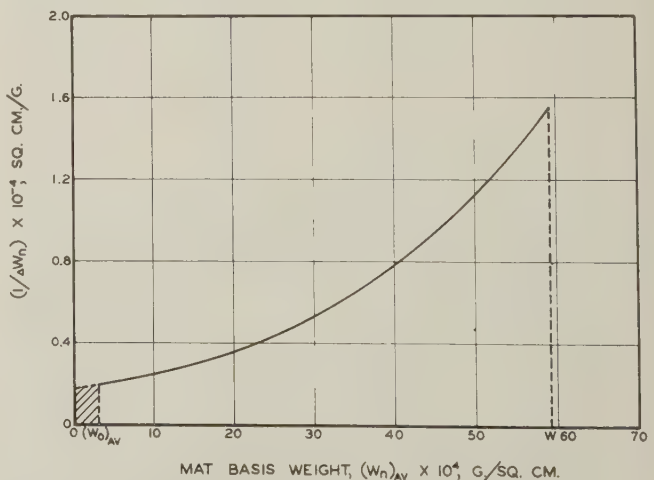

Fig. 5. Representation of curve area defining total number of table rolls from equation (14)

weight, $(W_n)_{av}$. Equation (11) may be arranged in a form equivalent to equation (12)

$$\int_0^W \frac{d(W_n)_{av}}{\Delta W_n} = \int_0^N dn = N \qquad (14)$$

The area under the curve in Fig. 5 equals the total number of table rolls, N, but because the integration has been carried out from a lower limit of $(W_n)_{av} = 0$, this area, and hence N, will be too large by the indicated shaded area. Strictly speaking, the integration should be carried out over the limits shown in equation (15):

$$\int_{(W_0)_{av}}^W \frac{d(W_n)_{av}}{\Delta W_n} = N \qquad (15)$$

where $(W_0)_{av}$ is the arithmetic average basis weight leaving the breast roll ($n = 0$). The use of a lower limit of $(W_n)_{av}$ of zero allows considerable simplification of the final integrated form in equation (13).

However, when equation (13) is applied to the whole table roll section and the number of rolls is relatively large, the error will not be great. For example, using the data for the bond furnish with $K = 6.72 \times 10^6$ and $W = 59.1 \times 10^{-4}$, equation (13) gives $N = 38$ as compared with the value of 37 based on the more rigorous summation in equation (15). This error is undoubtedly less than that involved in the laboratory estimation of the constants, k_1, k_2, and α, and it is concluded that equation (13) satisfactorily relates machine conditions to the laboratory-measured constants.

It was anticipated that the method of relating machine conditions to laboratory-measured values of specific resistance in the case of bond furnish would be reasonably accurate since the empirical factors involved in flocculation, effective compacting pressure, and effective wire resistance were determined from the machine data for this case. Therefore, machine data shown in Table I were obtained for a different fourdrinier machine operating with a board furnish of about four times the basis weight of the bond paper.

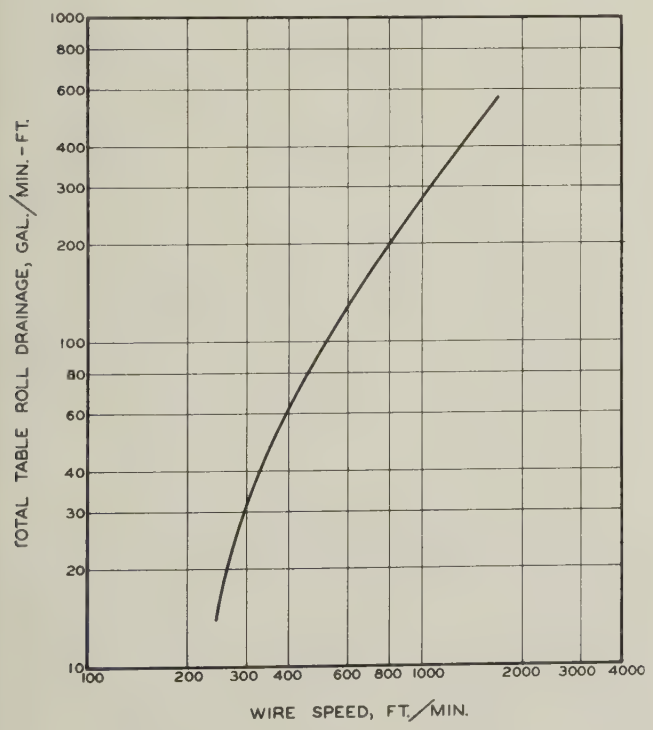

Fig. 6. Total table roll drainage calculated as a function of machine speed for board furnish

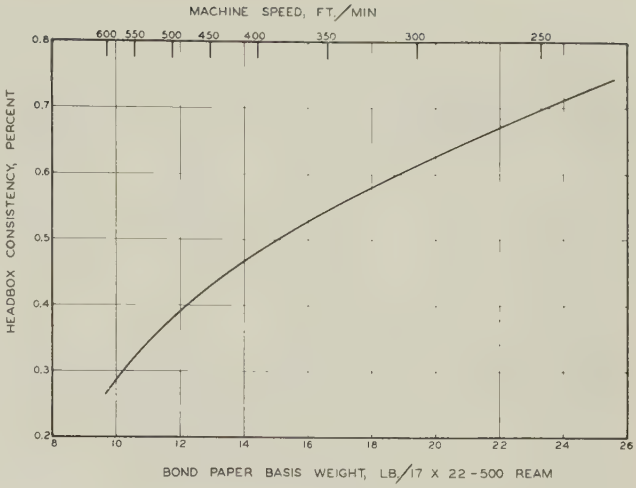

Fig. 7. Required headbox consistency for given basis weight at constant production rate of bond paper

Again, the first step in the calculation is to estimate the effective mat compacting pressure. The first trial assumes the effective pressure drop is $(1/20)$ $(1/2)$ ρU^2, or $(1/20)$ (7.78) = 0.39 cm. of water. Using the data from Fig. 3 and a wire resistance of 1.08×10^5 cm.$^{-1}$ gives the effective pressure, ΔP_e, as 0.32 and 0.31 cm. water for second and third trials, respectively, where

$$\Delta P_e = [(1/20)(1/2)\rho U^2] \frac{R_t - \alpha}{R_t} \qquad (16)$$

and the constants k_1 and k_2 used to evaluate R_6 are calculated from specific resistances at ΔP_3 and divided by a flocculation factor of 1.35. At $\Delta P_e = 0.31$ cm. water,

$$k_1 = 5.16 \times 10^8$$
$$k_2 = 0.0860 \times 10^8$$
$$m = 72.5$$

From equation (10), $K = 5.55 \times 10^7$. Solving equation (13) for the total number of table rolls, N, gives a value of 34 for a basis weight, W of 0.0211 g. per sq. cm. This compares favorably with the actual number of rolls of 37, and the validity of the method of analysis is supported.

ILLUSTRATIVE PROBLEMS

The working equations for relating paper machine operating variables to laboratory-measured values are equations (3), (4), (5), (10), (13), and (16). In addition, over-all drainage from the paper machine, Q, can be calculated from the summation of equation (7):

$$W = \sum_{n=0}^{n=N} \Delta W_n = \frac{s - w}{1 - sm} \frac{\rho}{UL} \sum_{n=0}^{n=N} q_n = \frac{(s - w)\rho Q}{(1 - sm)UL} \qquad (17)$$

As an example, consider the board furnish, with values of headbox consistency, s, white-water consistency, w, and basis weight, W, given in Table I. It is desired to estimate the total table roll drainage per unit wire width, Q/L, for forming this board at various machine speeds. At each speed, values of mat moisture content at an effective compacting pressure of ΔP_e, may be obtained from Fig. 2 and Q/L evaluated from equation (17). To calculate ΔP_e, the effective compacting pressure, a trial-and-error solution of equation (16) is obtained for each speed by using equations (3–5). Using the previous values of flocculation factor (1.35) and effective wire resistance (1.08×10^5) the data

Table II. Total Table Roll Drainage for Board Furnish

Wire speed, U f.p.m.	*$(1/20)(1/2)\ U^2$ cm. water*	*Effective compacting pressure, ΔP_e, cm. water*	*Mat moisture, m, g./g.*	*Drainage per unit width, Q/L, gal./min.-ft.*
243	0.39	0.31	72.5	14.1
300	0.59	0.50	65.0	30.2
400	1.05	0.96	55.3	62.0
600	2.37	2.17	45.0	128.5
1000	6.58	6.25	34.4	275
1500	14.80	14.20	27.0	475

Basis weight, $W = 0.0211$ g. per sq. cm.

shown in Table II are obtained. The relationship between total drainage and wire speed is shown in Fig. 6. At low speeds, the total drainage is roughly proportional to U^3, whereas at higher speeds, drainage varies about as $U^{3/2}$. The relationship depends upon both the mat compressibility and the relative mat and wire filtration resistance.

This calculation depends upon the assumption that the empirical pressure factor of $1/20$ is essentially independent of speed. Although the previous study (*1*) indicated it might be constant up to speeds of about 700 f. p. m., more paper machine data are definitely needed to establish accurate values of the compressibility factor.

As a second illustrative example of the use of the drainage equations, consider a common problem in the manufacture of bond paper. It is desired to make bond paper at the same production rate over a basis weight range of about 10 to 24 lb. $(17 \times 22 - 500)$. The production rate will be assumed to be that characterized by the data in Table I for the bond furnish, i. e., 343 f. p. m. producing a 15.7-lb. sheet at the table rolls (59.1×10^{-4} g. per sq. cm.) equivalent to a 17.0-lb. sheet (7.6% moisture) at the reel. Wire speed times basis weight will be maintained at this constant value, and the problem is to estimate the required headbox consistencies to complete the sheet formation on the table roll section. A sample calculation is detailed below for a basis weight at the reel of 10 lb.

Fixed Machine Conditions (from Table I):

White water consistency, $w = 0.00119$ g. per g.
White water viscosity, $\mu = 0.00762$ poise (90°F.)
Number of table rolls, $n = 39$ (38 calculated)
Table roll radius, $a = 5.72$ cm.

Variable machine data:

Basis weight at end of table rolls, $W = (59.1 \times 10^{-4})(10/17)\text{-}34.8 \times 10^{-4}$ g. per sq. cm.
Wire speed, $U = (343)(17/10) = 583$ f.p.m., 296 cm. per sec.
By trial and error, equations (3), (4), (5), and (16) give $\Delta P_e = 1.60$ cm. water for $\alpha = 1.08 \times 10^5$ cm.$^{-1}$ and flocculation factor of 1.35.
From Fig. 3, $R_0 = (1/1.35)(0.455 \times 10^8) = 0.337 \times 10^8 = k_2$. $R_w = (1/1.35)(1.64 \times 10^8) = 1.215 \times 10^8$. $k_1 = (1.215 - 0.337)(10^8)/(2 \times 34.8 \times 10^{-4}) = 126 \times 10^8$.
From equation (13), $K = 4.96 \times 10^6$.
From equation (10) with $m = 53.5$, $s = 0.00284$ g. per g.

Similar calculations for basis weights (at the reel) up to 24 lb. give the curve in Fig. 7 showing the relationship between headbox consistency, basis weight, and speed at a fixed production rate. This type of curve may be established for any stock from laboratory measurements of filtration resistance of whole stock, R_w, and stock with fines removed, R_0, and mat moisture content, m. All three of these variables must be determined as a function of pressure drop, over a pressure range equivalent to the effective compacting pressures, ΔP_e.

SUMMARY

A method of relating laboratory-measured values of specific filtration resistance and filter mat moisture content to drainage on the wire of the paper machine has been supported by reasonable checks of wire length (number of table rolls) on two different paper machines. The analysis of machine operation has shown the important effect of fines retained in the mat formed on the table roll section.

The stock analyzed in the laboratory should be equivalent to stock at the end of the table roll section. Either a couch roll sample or, if the white water system is essentially closed, a sample of stock going to the headbox will be representative of the mat formed at the end of the table roll section. The necessary laboratory measurements are: specific filtration resistance of the whole stock sample, specific filtration resistance of the sample with fines removed in a classification procedure, and moisture content of the filter mat. These determinations are conveniently made in a constant-rate filtration apparatus and must be known as a function of pressure drop across the mat.

Empirical factors are required to estimate (1) the effective compacting pressure acting on the mat on the machine wire, (2) the decrease in filtration resistance because of flocculation on the wire, and (3) the effective machine wire resistance. In this study, limited data from a single previous paper machine investigation (*1*) were used for estimates of the empirical factors. However, to make the method generally applicable to wider ranges of machine speeds, different headbox consistencies and different pulps, and different machine wires, studies should be made of the effect of these variables on the empirical factors. Information on the effect of varying headbox consistency, mat basis weight, and machine speed on fines retention and subsequent white water consistency would improve the accuracy of the analysis when these variables are changed over wide ranges.

When the laboratory data and empirical factors are obtained for a given stock, the drainage equations may be used for machine design, operation, or control. The most important paper machine variable is speed, which affects both the driving force causing drainage over the table rolls and the filtration resistance of the mat formed. The effect on machine drainage of changing furnish or refining conditions may be estimated from the laboratory data alone.

It is emphasized that this empirical approach will not increase understanding of the mechanisms of water removal from the paper machine. As previously noted (*1*), further advances in understanding of the papermaking process will depend largely on development of more fundamental knowledge in areas where empirical factors are now necessary.

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Chlorine Consumption of Unbleached Low Lignin Pulps by Tosylchloroamide Treatment

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This paper describes a study of the chlorine consumption of unbleached, low lignin pulps by acidified, aqueous tosylchloroamide solutions. When chlorine consumption was plotted against reaction time on a log-log scale, a straight-line relationship was exhibited for each of the pulp series investigated. The slopes deviated, however, when pulp series cooked by different processes and derived from different woods were compared. In each group of pulps, a distinct conversion factor to the Roe chlorine number was found. Distinct conversion factors were also found for the Klason-lignin. A new practical procedure for the tosylchlorination of pulps is outlined which gives much better reproducibility for low lignin pulps than either the Roe chlorine number or Klason lignin methods.

Chlorination of unbleached pulps is widely used in pulp mill control to determine pulp bleachability, and the chlorine consumption values are also used to estimate the residual lignin. This applies to the Roe chlorine number determination and its modifications (*1–4*). A further method suggested (*5*) is chlorination of acid hydrolyzate of unbleached pulps by hypochlorite (*5*).

The Roe chlorine number determination is practical for medium and even high lignin pulps (*6–8*). However, in the case of low lignin pulps, those, for instance, used to produce bleached dissolving grade pulps, the relationship between the chlorine consumption and the residual lignin is rather ambiguous.

In the production of high quality chemical pulps from low lignin unbleached pulps, it is known that the bleaching must be carried out carefully, and particular care must be taken that the amounts of chemicals used be in an appropriate relationship to the amount of the residual lignin. If a greater excess of bleaching agents is used, the pulp material tends to undergo noticeable degradation resulting in a quality decrease.

In our investigations an attempt was made to chlorinate low lignin pulps under mild conditions by an acidified tosylchloroamide (TSCA) solution and to determine the chlorine consumption titrimetrically. A series of pulps was studied and a practical method developed.

EXPERIMENTAL WORK

In preliminary investigations it was found that under constant temperature conditions (25°C.), several factors, especially the pH of the reaction mixture and the reaction time, influence the tosylchlorination of unbleached pulps. For a closer study, a series of experiments was carried out varying one factor at a time.

Acidity

In general, it was found that the rate of the chlorine consumption in the tosylchlorination of unbleached pulps increases with the acidity of the reaction mixture. When plotting the chlorine consumption versus the pH on a log-log scale a linear relationship was found. To avoid the influence of acidity variation, a constant pH of 1.0 by appropriate hydrochloric acid addition to the reaction mixture was chosen. It was also selected for comparison with the bromine consumption of the pulps (*9*), which is performed at this pH. By using this acidity, the question arose, whether the chlorine consumption would be increased by acid hydrolysis of the pulp materials. To study this, a series of experiments was carried out in which a bleached (lignin-free) dissolving pulp was subjected to hydrolysis by boiling with dilute sulphuric acid (pH of the reaction mixture was 1.5 simulating the acidity conditions of commercial bisulphite cooking) for various times. The chlorine consumption by tosylchlorination and the copper-number (*10*) of the pulp samples were determined (Table I).

Table I. Hydrolysis of a Bleached Dissolving Grade Pulp; Copper-Number and Chlorine Consumption Versus Time of Hydrolysis

Time of hydrolysis, hr.	*Copper-number*	*Chlorine consumption, % (3 hr. reaction time)*
0	1.25	0
6	2.68	0
12	3.19	0.08
18	3.82	0.09

The reaction temperature in the tosylchlorination was 25°C. As can be seen from Table I, during hydrolytic degradation of the pulp the copper-number increased, however, there was no appreciable chlorine consumption even after 3 hr. reaction time. Therefore, pulp hydrolysis is not a factor under the conditions of pulp tosylchlorination.

Reaction Temperature

A reaction temperature of 25°C. was generally used in the experiments. As described in the following the tosylchlorination of the pulp samples was carried out in so-called iodine flasks which were shaken by a wrist-action shaker while immersed in a water bath kept at 25° ±0.1°C.

Reaction Time

In order to study the influence of the reaction time, a series of unbleached coniferous sulphite pulps was subjected to tosylchlorination under constant conditions but at different reaction times (1, 2, 3, and 4 hr). The results obtained, listed in Table II, are also presented on log-log scale in Fig. 1.

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From Fig. 1, a straight-line relationship can be seen in all cases, indicating that the heterogeneous reaction of the pulp materials with tosylchloroamide follows an exponential function. It is noteworthy that the

Table II. Tosylchlorination of Unbleached, Coniferous Sulphite Pulps; Influence of the Reaction Time

Reaction time, hr. → / *Pulp sample*	*1*	*2*	*3*	*4*
	Chlorine consumption, %			
Spruce				
No. 1083	3.28	3.79	3.93	4.24
	3.28	3.81	3.93	4.28
No. 1084	2.39	2.69	3.03	3.14
	2.39	2.67	3.03	3.13
No. 6407	1.67	1.85	2.05	2.25
	1.65	1.89	2.06	2.16
No. 8315	1.45	1.72	1.88	2.04
	1.46	1.72	1.89	2.05
No. 5822	1.04	1.12	1.30	1.37
	1.04	1.12	1.30	1.37
No. 3125	0.40	0.45	0.49	0.54
	0.40	0.45	0.50	0.52
Mixture				
70% Spruce	1.67	1.98	2.22	2.22
30% Balsam Fir	1.67	1.96	2.14	2.22
Mixture Western Hemlock, Sitka Spruce, *Abies amabilis:*				
a	1.41	1.67	1.84	1.96
	1.41	1.67	1.84	1.98
b	1.05	1.20	1.34	1.44
	1.05	1.20	1.34	1.43
c	0.92	1.07	1.17	1.26
	0.92	1.07	1.19	1.26
Tamarack				
No. 1075 B	4.17	4.72	5.21	5.50
	4.29	4.77	5.20	5.42
No. 1075 A	3.73	4.37	4.72	4.91
	3.75	4.37	4.70	4.91
No. 1075 D	3.49	4.04	4.52	4.58
	3.55	4.05	4.52	4.61
No. 1075 C	3.28	3.83	4.05	4.28
	3.40	3.83	4.08	4.28
Jackpine				
No. 8138	2.66	3.04	3.18	3.40
	2.64	3.01	3.18	3.40

straight lines for the coniferous sulphite pulps investigated were found to be parallel.

For comparison, a series of hardwood sulphite

Table III. Tosylchlorination of Unbleached Hardwood Sulphite Pulps; Influence of the Reaction Time

Reaction time, hr. → / *Pulp sample*	*1*	*2*	*3*	*4*
	Chlorine consumption, %			
Elm				
No. 8015	3.49	3.83	4.00	4.27
	3.44	3.77	4.00	4.26
No. 1080	3.00	3.32	3.46	3.60
	2.98	3.30	3.48	3.66
No. 999	2.12	2.33	2.49	2.60
	2.13	2.32	2.47	2.60
No. 998	2.05	2.29	2.45	2.58
	2.08	2.31	2.47	2.56
White Birch				
No. 7001	1.60	1.77	1.87	1.99
	1.60	1.77	1.84	1.99
Maple				
No. 7502	0.88	1.03	1.07	1.15
	0.89	1.01	1.07	1.09

(Table III) and sulphate pulps (Table IV) was also investigated. The data are presented on log-log scale (Fig. 2 and 3).

As can be observed from Figs. 2 and 3, the data of the hardwood pulps presented on log-log scale also exhibit a straight-line relationship between chlorine consumption and reaction time. Comparing the families of straight lines obtained from coniferous and hardwood

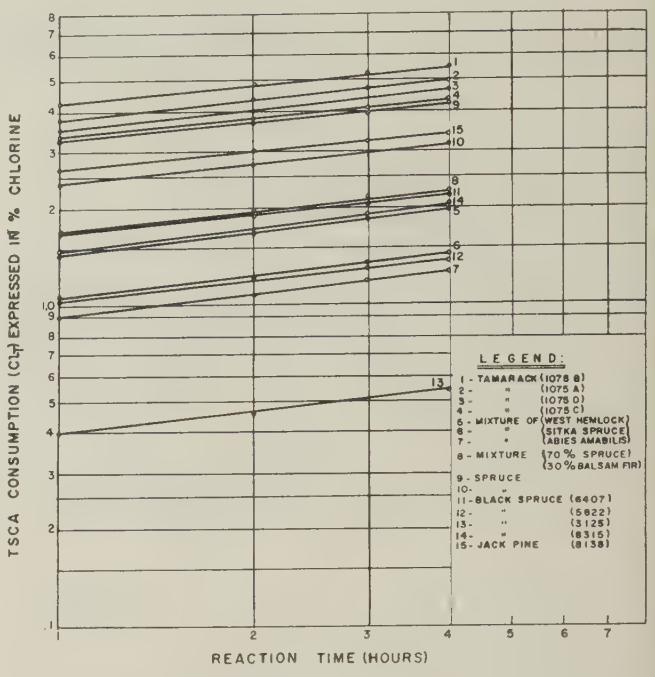
TSCA CONSUMPTION (Cl) EXPRESSED IN % CHLORINE
REACTION TIME (HOURS)
LEGEND:
1 - TAMARACK (1078 B)
2 - " (1075 A)
3 - " (1075 D)
4 - " (1075 C)
5 - MIXTURE OF (WEST HEMLOCK)
6 - " (SITKA SPRUCE)
7 - " (ABIES AMABILIS)
8 - MIXTURE (70 % SPRUCE) (30 % BALSAM FIR)
9 - SPRUCE
10 - "
11 - BLACK SPRUCE (6407)
12 - " (5822)
13 - " (3125)
14 - " (8315)
15 - JACK PINE (8138)

Fig. 1. TSCA consumption versus reaction time, coniferous sulphite pulps

pulps, it is apparent that there exist different slopes for different types of pulps.

Tosylchloroamide Surplus

In earlier work (*9*) on the bromination of unbleached pulps it was found that the halogen consumption in-

Table IV. Tosylchlorination of Unbleached Sulphate Pulps; Influence of the Reaction Time

Reaction time, hr. → / *Pulp sample*	*1*	*2*	*3*	*4*
	Chlorine consumption, %			
Poplar				
No. 1035	2.49	2.73	2.93	2.99
	2.45	2.71	2.91	2.99
No. 1025	2.02	2.19	2.35	2.44
	2.02	2.19	2.35	2.44
No. 1034	1.97	2.16	2.30	2.40
	2.00	2.18	2.27	2.40
No. 1008	1.93	2.13	2.25	2.36
	1.93	2.12	2.25	2.34
No. 1053	1.66	1.80	1.93	1.99
	1.67	1.80	1.88	1.99
No. 1052	1.56	1.67	1.78	1.81
	1.54	1.67	1.78	1.84
No. 1007	1.51	1.62	1.71	1.76
	1.51	1.62	1.71	1.76

creased with the amount of the halogen present, until, with a residual amount of about 70% or more at the end of the reaction time, the influence of the halogen surplus was nearly constant. This was found to be valid also for the tosylchlorination of pulps. For this reason, in the experimental work a tosylchloroamide excess of not less than 70% was used.

CHLORINE CONSUMPTION IN PULP TOSYLCHLORINATION AND ROE CHLORINE NUMBER

Comparison of the chlorine consumption in pulp tosylchlorination with that in the Roe-chlorine number determination was of practical interest. A series of coniferous sulphite pulps was studied (Table V). A linear relationship was found to exist, but, with a distinct slope for each reaction time used in the tosylchlorination. This indicates that the tosylchloroamide consumption and the Roe-chlorine number can be compared when correction is made for the reaction time used (conversion factor).

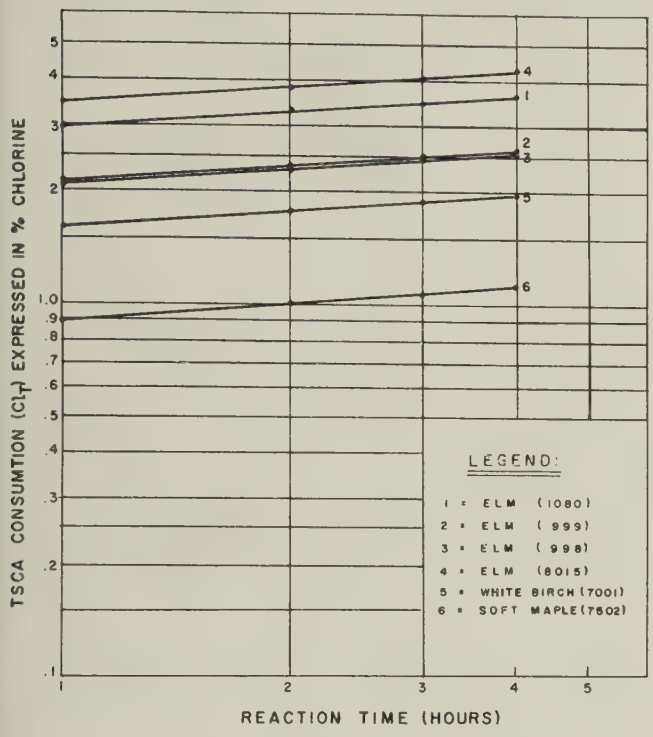
TSCA CONSUMTION (Cl$_T$) EXPRESSED IN % CHLORINE
REACTION TIME (HOURS)
LEGEND:
1 = ELM (1080)
2 = ELM (999)
3 = ELM (998)
4 = ELM (8015)
5 = WHITE BIRCH (7001)
6 = SOFT MAPLE (7502)

Fig. 2. TSCA consumption versus reaction time, hardwood sulphite pulps

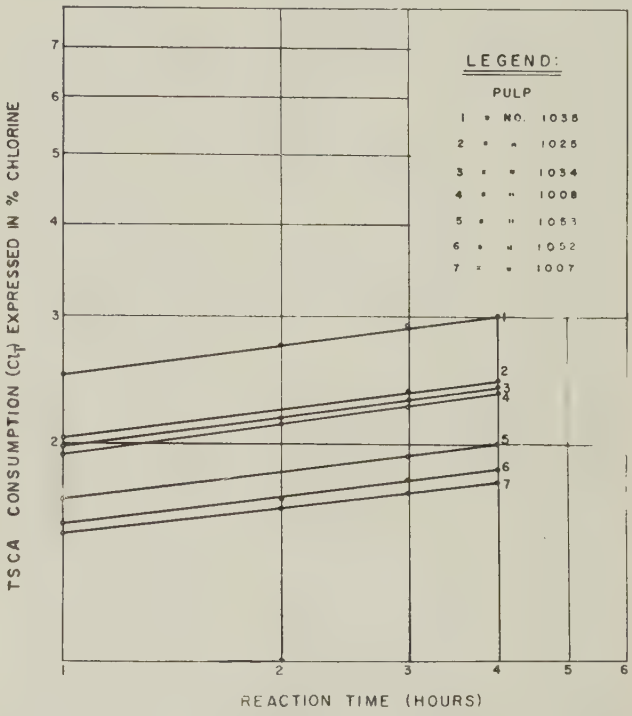

Fig. 3. TSCA consumption versus reaction time, poplar sulphate pulps

The tosylchloroamide consumption of softwood sulphite pulps was also compared with the Kappa number (*11*). A linear relationship was found between the chlorine and the permanganate consumption (Fig. 4).

In order to study tosylchlorination of unbleached

Table V. Chlorine Consumption in Tosylchlorination and Roe Chlorine Number Determination; Coniferous Pulps

Pulp sample	*Kappa number*	*Chlorine consumption, %: Tosylchlorination (Cl_T); reaction time 1 hr.*	*Chlorine consumption, %: Roe number; (Cl_R)*	Cl_R/Cl_T
Spruce				
No. 1083	39.8	3.28	7.29	
		3.28	7.47	2.22
No. 1084	30.0	2.39	5.72	
		2.39	5.70	2.38
No. 6407	20.0	1.68	...	
		1.65	3.7	2.22
No. 8315	19.3	1.45	3.43	
		1.46	3.31	2.33
No. 5822	10.5	1.04	2.3	
		1.04	...	2.21
No. 3125	4.0	0.40	1.1	
		0.40	...	2.51
Mixture				
70% Spruce	...	1.67	3.97	
30% Balsam Fir	...	1.67	3.92	2.33
Tamarack				
No 1075 B	46.8	4.17	9.19	
		4.29	9.42	2.19
No. 1075 A	43.0	3.73	8.46	
		3.75	8.62	2.26
No. 1075 D	42.3	3.49	8.27	
		3.55	8.43	2.37
No. 1075 C	37.4	3.28	7.47	
		3.40	7.62	2.23
Jackpine				
No. 8138	31.4	2.66	5.74	
		2.64	5.66	2.15

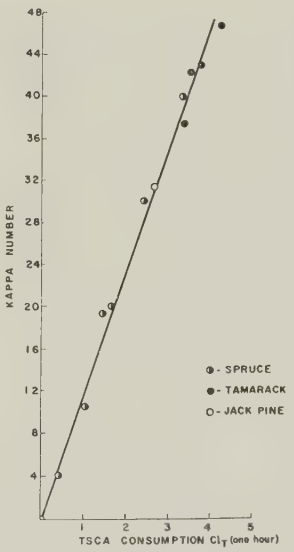

Fig. 4. TSCA consumption versus Kappa number, coniferous sulphite pulps

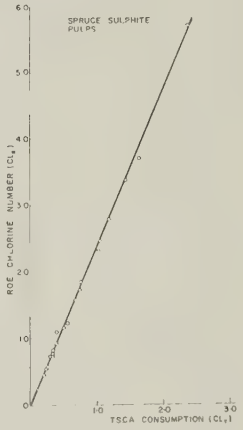

Fig. 5. TSCA consumption versus Roe chlorine number

In order to study tosylchlorination of unbleached

pulps of extremely low lignin content, homogeneous mixtures of finely ground pulps of known lignin content and of bleached, lignin-free pulps were prepared in different proportions, and the mixtures subjected to the

Table VI. Chlorine Consumption in Tosylchlorination of Sulphite Black Spruce Pulp Mixtures

Pulp sample	Ratio of mixture	Chlorine consumption, %: Tosylchlorination (Cl_T); reaction time, 1 hr.	Chlorine consumption, %: Roe number; calculated (Cl_R)	Cl_R/Cl_T
No. 6407	3:1	1.18		
		1.19	2.77	2.33
No. 6407	2:1	1.07		
		1.06	2.46	2.30
No. 5822	4:1	0.78		
		0.80	1.85	2.32
No. 6407	1:1	0.77		
		0.77	1.85	2.40
No. 5822	3:1	0.76		
		0.76	1.72	2.26
No. 5822	2:1	0.68		
		0.69	1.53	2.22
No 6407	1:2	0.57		
		0.57	1.23	2.16
No. 5822	1:1	0.51		
		0.51	1.15	2.25
No. 6407	1:3	0.41		
		0.41	0.92	2.25
No. 3125	3:1	0.36		
		0.36	0.82	2.29
No. 6407	1:4	0.35		
		0.35	0.74	2.11
No. 5822	1:2	0.34		
		0.34	0.77	2.26
No. 3125	2:1	0.32		
		0.30	0.73	2.28
No. 5822	1:3	0.26		
		0.25	0.57	2.21
No. 3125	1:1	0.25		
		0.25	0.55	2.20
No. 5822	1:4	0.21		
		0.21	0.46	2.18

tosylchlorination procedure. The experimental data were compared with the Roe chlorine numbers of the

Table VII. Chlorine Consumption in Tosylchlorination and Roe Chlorine Number Determination; Hardwood Sulphite Pulps

Pulp sample	Chlorine consumption, %: Tosylchlorination (Cl_T); reaction time, 1 hr.	Chlorine consumption, %: Roe number; (Cl_R)	Cl_R/Cl_T
Elm			
No. 8015	3.49	7.27	
	3.44	7.10	2.07
No. 1080	3.00	5.69	
	2.98	5.82	1.92
No. 999	2.12	4.13	
	2.13	4.15	1.88
No. 998	2.05	3.89	
	2.08	3.94	1.93
White Birch			
No. 7001	1.60	2.52	
	1.60	2.40	1.56
Maple	0.88	1.12	
No. 7502	0.89	1.40	1.46

mixtures calculated from those of the initial pulps. The results obtained are presented in Table VI and Fig. 5.

The TSCA data also have been evaluated statistically together with the four initial pulps used (No. 6407, 8315, 5822, and 3125, Table V). The following was found:

Average level	0.67
Standard deviation	0.007
Coefficient of variation	1.0%

The low standard deviation (0.007) found indicates a good reproducibility of the tosylchlorination results.

Table VIII. Chlorine Consumption in Tosylchlorination and Roe Chlorine Number Determination; Poplar Sulphate Pulps

Pulp sample	Chlorine consumption, %: Tosylchlorination (Cl_T); reaction time, 1 hr.	Chlorine consumption, %: Roe number; (Cl_R)	Cl_R/Cl_T
No. 1025	2.02	3.13	
	2.02	3.05	1.53
No. 1034	1.97	3.03	
	2.00	3.00	1.51
No. 1008	1.93	2.83	
	1.93	2.70	1.45
No. 1052	1.56	2.20	
	1.54	2.15	1.42

As shown by Mitchell (*12*), the standard deviation of chlorine number determinations does not drop much below 0.09 for very low lignin pulps. Thus, the coefficient of variation for pulps of, say chlorine number

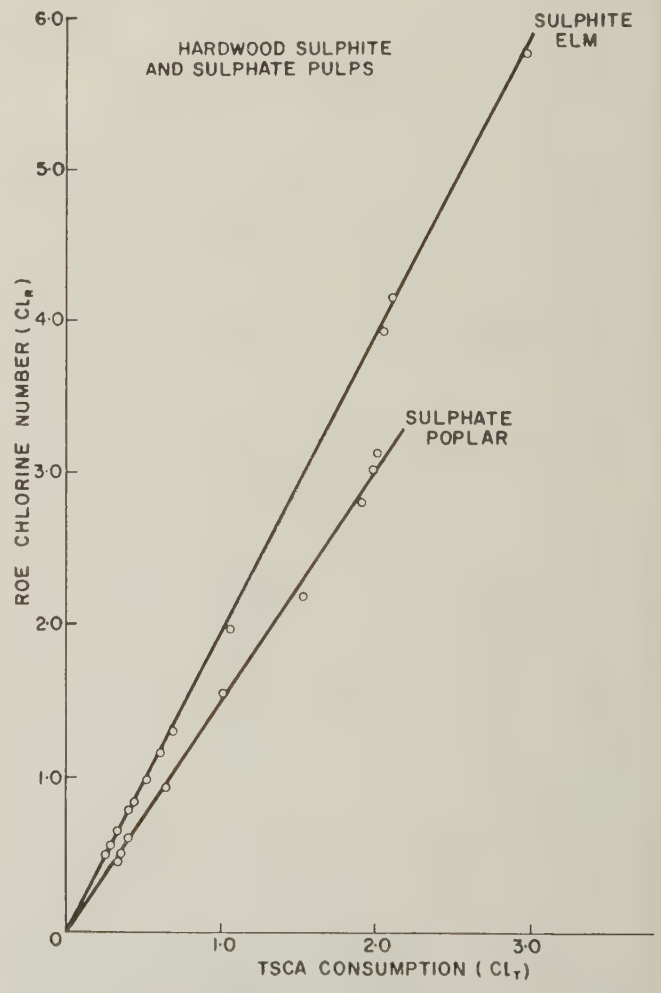

Fig. 6. TSCA consumption versus Roe chlorine number

1.0 is about 9%. For the TSCA method, the coefficient of variation is in the vicinity of only 1%.

The relationship between the chlorine consumption in the tosylchlorination and Roe chlorine number determination was also studied for hardwood sulphite and sulphate pulps (Tables VII and VIII).

Table IX. Chlorine Consumption in Tosylchlorination of Sulphite Elm Pulp Mixtures

Pulp sample	Ratio of mixture	Chlorine consumption, %: Tosylchlorination (Cl_T); reaction time, 1 hr.	Chlorine consumption, %: Roe number; calculated (Cl_R)	Cl_R/Cl_T
No. 998	1:1	1.07	1.94	
		1.07	1.97	1.83
No. 998	1:2	0.69	1.29	
		0.69	1.31	1.88
No. 1080	1:4	0.61	1.14	
		0.62	1.16	1.86
No. 998	1:3	0.53	0.97	
		0.53	0.98	1.85
No. 1080	1:6	0.44	0.81	
		0.44	0.83	1.86
No. 998	1:4	0.40	0.78	
		0.40	0.78	1.95
No. 998	1:5	0.34	0.65	
		0.34	0.65	1.91
No. 998	1:6	0.30	0.56	
		0.30	0.55	1.86
No. 998	1:7	0.26	0.49	
		0.26	0.49	1.88
No. 998	1:8	0.23	0.43	
		0.23	0.44	1.91

In addition, a few of these hardwood pulps in a finely ground state were blended with varying amounts

Table X. Chlorine Consumption in Tosylchlorination of Sulphate Poplar Pulp Mixtures

Pulp sample	Ratio of mixture	Chlorine consumption, %: Tosylchlorination (Cl_T); reaction time, 1 hr.	Chlorine consumption, %: Roe number; calculated (Cl_R)	(Cl_R/Cl_T)
No. 1025	1:1	1.03	1.57	
		1.02	1.52	1.50
No. 1008	1:2	0.65	0.94	
		0.65	0.90	1.41
No. 1034	1:4	0.41	0.61	
		0.41	0.60	1.49
No. 1034	1:5	0.35	0.51	
		0.35	0.50	1.45
No. 1052	1:4	0.34	0.44	
		0.34	0.43	1.30

of a ground lignin-free pulp as described above, and the mixtures subjected to the tosylchlorination procedure. The chlorine consumption and the calculated Roe chlorine numbers are listed in Tables IX and X and are also presented in Fig. 6. Straight lines were obtained with different slopes.

Chlorine Consumption and Methoxyl Content

Since the methoxyl content of unbleached pulps is considered to be an approximate index of the lignin content, the relation between the chlorine consumption in pulp tosylchlorination and the pulp methoxyl content was also studied. A series of coniferous sulphite pulps and hardwood sulphite and sulphate pulps was investigated (Table XI).

In earlier investigations of the bromination of unbleached pulps (*9*), a straight-line relationship was found between the halogen consumption and the methoxyl content. As can be seen from Table XI, a similar relation is evident between the chlorine consumption in tosylchlorination and the methoxyl content, when constant reaction conditions are used in the tosylchloro-

Table XI. Chlorine Consumption and Methoxyl Content (Various Pulps)

Pulp sample	Chlorine consumption, % (Cl_T); reaction time, 1 hr.	Methoxyl, %	Atoms Cl to 1 mole methoxyl
	Sulphite Pulps		
Tamarack			
No. 1075 B	4.23	1.12	3.31
No. 1075 A	3.74	1.00	3.27
No. 1075 D	3.52	1.00	3.10
No. 1075 C	3.34	0.89	3.28
Mixtures of Western Hemlock, Sitka Spruce, *Abies amabilis*			
a	1.41	0.47	2.63
b	1.05	0.40	2.31
c	0.92	0.29	2.78
Elm			
No. 999	2.13	0.79	2.36
No. 998	2.07	0.77	2.35
	Sulphate Pulps		
Poplar			
No. 1035	2.47	0.82	2.63
No. 1025	2.02	0.60	2.94
No. 1034	1.98	0.60	2.89
No. 1008	1.93	0.58	2.91
No. 1053	1.67	0.48	3.05
No. 1052	1.55	0.46	2.95
No. 1007	1.51	0.44	3.00

amide treatment. However, the slopes differ for different wood species and cooking conditions.

CHLORINE CONSUMPTION IN PULP TOSYLCHLORINATION AND PULP KLASON LIGNIN CONTENT

Since the chlorine consumption in the Roe chlorine number determination is sometimes used as a measure of the pulp lignin content, this relationship was also studied in the tosylchlorination of various unbleached pulps. As can be seen from Table XII there are appreciable deviations in the ratio of the chlorine consumption (Cl_T) to the Klason lignin when pulps from various woods and cooked under different conditions are compared. Not unexpectedly, there exists no general conversion factor for lignin, which could be used for soft and hardwood pulps both.

The Tosylchlorination Method

For the determination of the chlorine consumption in pulp tosylchlorination, the following apparatus and reagents are required:

Apparatus:

Three 500-ml. iodine flasks.
One 50-ml. pipet.
One 50-ml. graduated cylinder.
One 50-ml. buret.
One wrist-action shaker with constant temperature bath.
One stop watch.

Reagents:

0.25 *N* tosylchloroamide solution (5.634 g. in 1000 ml. dist. water).
0.25 *N* sodium thiosulphate solution.
0.36 *N* hydrochloric acid.
20% potassium iodide solution.
1% starch solution or Thiodene.

Procedure: Weigh accurately in duplicate 0.500 g. samples (0.250 or less if the Roe chlorine number of the pulp is higher than 5.0) of the air-dry pulp. The

Table XII. Pulp Tosylchlorination and Pulp Klason Lignin (Various Pulps)

Pulp sample	*Chlorine consumption, % (Cl_T); reaction time, 1 hr.*	*Klason-lignin, %*	*Weight ratio, Cl_T:-Klason-lignin*
	Sulphite Pulps		
Tamarack			
No. 1075 B	4.23	6.4	0.66
No. 1075 A	3.74	6.0	0.62
No. 1075 D	3.52	5.7	0.62
No. 1075 C	3.34	5.2	0.64
Mixture of 70% Spruce and 30% Balsam Fir	1.67	3.1	0.54
	Sulphate Pulps		
Poplar			
No. 1035	2.47	3.8	0.65
No. 1025	2.02	2.7	0.75
No. 1034	1.98	2.8	0.71
No. 1008	1.93	2.6	0.74
No. 1053	1.67	2.1	0.80
No. 1052	1.55	2.1	0.74
No. 1007	1.51	1.9	0.79

original pulp sample must be representative and, particularly, must be exhaustively washed and homogenized. Before analysis, the pulp sample has to be ground in a Wiley mill to a particle size passing mesh no. 40. Determine the moisture content of the ground material. Introduce the samples into dry iodine flasks and add with a pipet 50 ml. of the 0.25 *N* tosylchloroamide solution. Acidify to a pH of 1 by rapid addition of 30 ml. of 0.36 *N* HCl solution contained in a graduated cylinder. The flasks are immediately closed, water sealed and immersed into a water bath kept at the constant temperature of 25° ± 0.1°C. Shake gently by means of a wrist-action shaker for 1 hr. At the end of the reaction time, remove the flasks from the water bath and replace the water seal with about 10 ml. of the 20% KI solution. Lift the stopper for a moment, and then quickly introduce the potassium iodide solution into the flask, which is immediately restoppered and slightly shaken. Back titrate the iodine surplus with 0.25 *N* thiosulphate solution until the reddish-brown color of the mixture changes to yellow. The stopper and the inside of the flask are rinsed with distilled water and then starch solution or Thiodene is added. Continue the titration until disappearance of the blue color. Calculate the chlorine consumption Cl_T on the oven-dry weight of the pulp sample. It is desirable to run concurrently a blank with each determination and to correct for the small blank value.

To confirm the reproducibility of the new method in the low lignin range, a blend of ground, unbleached black spruce sulphite pulp and a lignin-free bleached pulp was tosylchlorinated 20 times and the results obtained (Table XIII) evaluated statistically.

DISCUSSION AND CONCLUSION

So far, no accurate methods for the lignin determination in unbleached low lignin pulps are in existence. The Roe chlorine number determination, which is a

Table XIII

Group of 20 replicates chlorine consumption, % (Cl_T)			
0.514	0.520	0.515	0.515
0.529	0.512	0.525	0.518
0.526	0.511	0.510	0.510
0.528	0.512	0.520	0.505
0.509	0.526	0.515	0.512

The following was found; Average level 0.52; standard deviation 0.007; and coefficient of variation 1.3%.

practical method for determining pulp bleachability, does not give reproducible results in the low lignin range, because of its limitations as a gas-volumetric method. Neither is the Klason-lignin determination according to TAPPI Standard T 222 m-50 reliable in its application to low lignin pulps. This applies also for the determination of the methoxyl groups below values of about 0.5%. Earlier investigations indicated that halogen consumption of unbleached pulps under controlled conditions is directly related to the residual lignin. Pulp chlorination by means of an acidified (pH 1) aqueous tosylchloroamide solution was adopted, with back titration of the reagent surplus at the end of the reaction time. This titrimetric procedure using an extended reaction time of 1 hr., a reaction temperature of 25°C., and a minimum surplus of 70% of the reagent (0.25 *N* solution) was found to give reproducible results, which can also be used as a measure of the residual lignin, provided that the specific conversion factor for the pulp material has been empirically determined.

When comparing the Roe chlorine figures of coniferous sulphite pulps with those of the chlorine consumption in tosylchlorination, a fairly constant ratio was found of about 2.26 which can be used for conversion purposes. However, for hardwood sulphite and sulphate pulps, the figures found were different, indicating that for pulps derived from different woods and cooked by different processes, distinct conversion factors exist. There are also differences in the ratio between the atoms chlorine consumed and the moles methoxyl present, as well as in the lignin conversion factors. This is an indication that no general conversion factor for lignin exists, which could be used both for soft and hardwood pulps. The new chlorination method gives reproducible results particularly in the low lignin range (Roe number below 4).

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Mechanical Properties of Wood Fibers

B. A. JAYNE

A technique is described for measuring the tensile mechanical properties of single fibers of wood using a conventional testing machine and small, specially fabricated grips for fixing the ends of the fiber. The results of several tests of three coniferous species revealed inherent differences in the load-deformation relationship of early as compared to latewood fibers. It is probable that variation in the minute structure of the cell wall is responsible for the observed differences. The existence of a limit of proportionality between stress and strain indicates that the fibers possess viscoelastic characteristics. It is suggested that a complete description of their properties must rely on several types of fundamental mechanical tests, all of which recognize time as a variable. Considering their fundamental nature, mechanical tests of individual wood fibers should prove to be of value not only to the research forester interested in gaging the effect of tree improvement practices on wood properties but also to the paper technologist concerned with the prediction of the properties of paper and estimation of the effects of mill processing variables on fiber properties.

SINCE the turn of the century the textile industry has recognized the importance of acquiring a thorough knowledge of the mechanical properties of fibers in order to predict, with some degree of certainty, the performance of fabrics subjected to service conditions as well as to gain better insight of the relationship between molecular structure and fiber deformation. Intensive research into the mechanics of textile fibers was stimulated by Leaderman (*6*) approximately two decades ago and since that time numerous investigators, of whom Alfrey (*1*), Eyring and co-workers (*3*), Meredith, (*8*), Pierce (*9*), and Hermanns (*5*) are but a few, have contributed to a clarification of the rheology of fibers. More than anything their work has demonstrated that a complete understanding of the mechanical properties of textile fibers rests not simply on a knowledge of strength alone but must include the fundamental interrelationship of load, deformation, and time. From a recognition of the time dependence of fiber mechanical properties, it follows that fibers possess viscous in addition to elastic characteristics. Gross (*4*) has proposed several methods for describing the properties of viscoelastic materials all of which relate stress, strain, and time.

It is very likely that wood fibers, which are similar structurally to many textile fibers, also possess similar mechanical characteristics. It appears, therefore, that an adequate description of their properties also should recognize the load-deformation-time interrelationship. Unfortunately, a fundamental approach to the mechanical characteristics of papermaking fibers has been lacking. It is interesting to note, however, that Clark (*2*), who developed a modification of the "zero-span" tensile test for paper, recognized some time ago the importance of fiber strength as one of the fundamental properties of pulp. He believed that the smallness of the fiber discouraged much investigation of its strength. Clark cites the work of Rühlemann (*10*), who measured the tensile strengths of single fibers from several sprucewood pulps, both bleached and unbleached, and found that breaking loads of early and latewood fibers ranged from 3 to 30 g. with averages of 10 and 12 g. "Stretch" of these same fibers varied from 3 to 8% with averages of 4.4 and 6.1%. Apparently, the relationship of load and deformation was not studied closely. Wardrop (*13*) measured the breaking stress of earlywood fibers of *Pinus radiata* and reports values ranging from 7.8 to 13.0 kg. per sq. mm. He noted also that breaking stress increased with increasing fiber length. Van den Akker, *et al.* (*12*), demonstrated recently the importance of fiber strength to the tearing and tensile strength of paper. Their work showed that a large percentage of fibers break when paper is torn or ruptured in tension. Whereas in the past it was thought that paper strength was almost entirely governed by the extent of interfiber bonding, it now appears that the strength of the fibers is of equal importance.

The findings of Van den Akker *et al.* relative to the partial dependence of paper strength of fiber strength suggest that mechanical properties other than breaking load may also affect paper characteristics. At present nothing is known of wood fiber stiffness, including shear and Young's modulus, work to failure, stress relaxation, and creep—a few of the mechanical properties of fibers commonly measured in the textile industry. It is very probable that these and other rheological properties of wood fibers can provide a part of the basic data now being used for fundamental comparisons of different species of wood and sources of fiber as well as for estimation of paper characteristics.

Though concerned primarily with volume production the forester has come to recognize the quality of wood as a factor deserving equal consideration. The research forester has used fiber dimensions, including length and cell-wall thickness, as measures of fiber quality, while specific gravity, as reflected by the relative proportions of early- and latewood, has received attention as a measure of gross wood quality. Important as these factors may be to the nature of the paper sheet, none reflect the molecular structure of the fiber—a characteristic that is proving to be of equal importance. It has long been recognized that the orientation of the cellulose molecules in the cell wall with respect to the longitudinal axis of the fiber, as commonly measured by fibril angle, has an important bearing on the mechanical properties of wood. In recognition of this fact foresters have undertaken to control fibril angle through tree breeding. Although this procedure may result in a fiber of greater strength, its effect on the many other mechanical properties is as yet unknown. On the other hand,

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direct measurement of fiber mechanical properties can yield some of the fundamental information needed by both the research forester and the paper technologist. It provides within a single experimental framework, indirect basic knowledge of the molecular architecture of the fiber and at the same time gives information of immediate application in paper manufacture.

SCOPE

This paper describes a technique for measuring the load-deformation relationship of single fibers of wood in tension. The fibers were deformed at a rate of 0.005 in. per min. under ambient conditions of 72°F. and 50 ± 2 % R.H. Both early and latewood fibers from pulps of Douglas-fir (*Pseudotsuga menziesii*), cypress (*Taxodium distichum*), and white spruce (*Picea glauca*) were tested to failure. Data collected include tensile strength, proportional limit stress, Young's modulus, work to failure, and deformation at failure.

EXPERIMENTAL

Material Preparation

Air-dried stock of the three species, exhibiting 10 to 20 rings per radial inch of cross-sectional surface, were pulped using a technique similar to the types reported by Spearin and Isenberg (*11*), Lovell (*7*), and Wise, *et al.* (*14*). Essentially the method consists of chlorinating the lignin in small chips of wood through the action of sodium chlorite in a dilute acid solution. After chlorination the lignin is water soluble, and vigorous agitation will disperse the chips into their component fibers. Small samples of each species, including both early and latewood, were reduced to chips approximately $^1/_8$ by $^1/_8$ in. in cross section and $^1/_2$ in. along the grain. A 5-g. sample of each species was placed in a 400-ml. beaker, covered with distilled water, and the mixture was boiled until the chips were completely saturated. Subsequently, the chips were drained and placed in a 250-ml. Erlenmeyer flask where they were covered with 150 ml. of distilled water containing 25 drops of glacial acetic acid and 2.5 g. of sodium chlorite. The solution including the wood chips was brought to and maintained at a temperature of 80°C. for a period of 1 hr. This cycle was repeated a total of four times and, following the fourth treatment, the chips were dispersed into fibers by vigorous agitation. The resulting pulps were thoroughly washed with tap water until all traces of chlorine had been removed and were then stored in distilled water. Wise, *et al.* (*14*), who have described a similar pulping method, report that their pulps were rich in hemicelluloses and contained from 1 to 2% lignin. It appears, therefore, that the technique will produce a fiber, virtually free of lignin, yet maintaining the essential nature of the cellulosic portion of the cell wall. The chemical composition of the fibers used in this study is not known.

A dilute slurry of the fibers of each species was placed in a watch glass or on the bottom of an inverted 250-ml. flask. Unbroken fibers, free of any obvious cell-wall abrasions, were selected with a pair of jeweler's tweezers while observing the fibers through a binocular microscope at 30× magnification. Each fiber was handled at an end to avoid damage to the central section which was scheduled for testing. Early- and latewood fibers were transferred to separate 1 by 3-in. glass slides while still in a saturated condition. The moderate forces of adhesion which developed immediately between the moist fiber and the glass restricted the amount of twisting the fiber could undergo while coming to a moisture content in equilibrium with room conditions. Fibers were taken directly from the slides for testing.

Mechanical Testing

The greatest obstacles to testing wood fibers have been the lack of suitable techniques and equipment for measurement of minute forces and deformation. Careful handling at the ends of the fibers with a pair of jeweler's tweezers eliminated the possibility of damage to the test zone. However, fixing the ends of the fibers required considerable experimentation. Previous investigators overcame this difficulty by gluing each end of a fiber to fine thread with a dental cement (*13*) or by bonding the ends of the fiber to strips of paper (*12*). The thread or paper could be gripped by conventional means for testing. Initially a procedure of this general type was attempted with the exception that fine wire and a special jig were used in lieu of thread or paper. A variety of adhesives including types that set by loss of solvent as well as those that undergo polymerization were used for bonding the ends of the fiber to the wire. When placed on the end of a wire a small drop of an adhesive which sets by loss of solvent, such as nitrocellulose, skims over in a few seconds thus preventing insertion of the fiber into the center of the small globule of still liquid cement. A fiber could be inserted into a small drop of most of the synthetic adhesives with no difficulty; however, the extended curing time of these adhesives unduly prolonged testing. Eastman 910, a synthetic adhesive of recent development, overcame previous objections to adhesives. This particular glue is characterized by a low surface tension and remains liquid for a period of approximately 1 min. when isolated in small quantities. However, it will polymerize within 2 to 3 min. Exploratory tests were undertaken with Eastman 910 as well as a urea and phenol-formaldehyde resin. Results showed that failure nearly always occurred at the point of bonding; an indication of a high concentration of stress in the zone of failure, due probably to the marked contrast in Young's modulus between adhesive and wood fiber and also to possible eccentricity of load on the fiber.

Subsequent efforts were directed toward the development of a pair of small lightweight grips which would develop sufficient friction between fiber and grip faces to prevent slipping of the fiber during application of load. It was found that a common machinist's pin vise, suitably modified, provided a gripping fixture having the desirable attributes of rapid, simple operation and positive gripping action. The original four-pronged gripping fixture of the pin vise was replaced by a two-pronged member, the recessed faces of which were covered with no. 400A silicon carbide, finishing paper. This material not only acted as a cushion to cover the metal surfaces of the grip and prevent rending of the fiber at the grip but also developed sufficient frictional resistance to eliminate slippage of the fiber. Drawings of one grip, to scale, are shown in Fig. 1. A wood fiber in place for testing is pictured in Fig. 2.

Tensile tests were carried out in an Instron, Model TTCL testing machine using a type-A load cell. Each

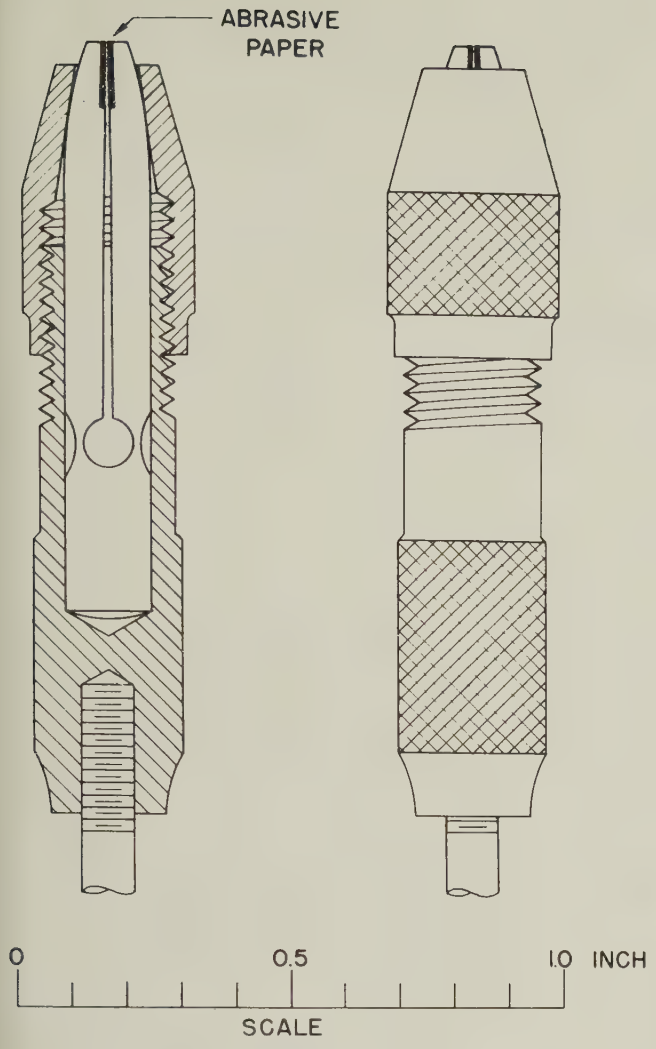

Fig. 1. Plan and sectional view of a fiber grip

fiber was centered in the jaws of the upper grip using a binocular microscope, and moderate pressure was brought to bear on the fiber by adjustment of the pin vise cap. After transferring the fiber and grip to the testing machine the movable crosshead, to which was attached the lower grip, was brought into a position that left a distance of 0.1 in. between grips. The fiber was then centered in the lower grip and clamped. An initial gage length of 0.1 in. insured the protrusion of at least 0.03 in. of the fibers tested within the jaws of each grip. The load-deformation relationship was plotted automatically for each fiber, using a fiber deformation rate of 0.005 in. per min. The amplified electrical output of the load cell was recorded directly on the x-axis of the x-time recorder. Deformation of the fiber was recorded on the y-axis by adjusting the rate of motion of the chart at a ratio convenient to the rate of fiber elongation. A chart speed of 5 in. per min., which allowed a magnification of fiber deformation of 1000×, permitted accurate interpretation of mechanical properties from the load-deformation plots. The electromechanical system of the Instron plotted both axes of the load-deformation relationships to an accuracy of better than ± 1%.

Measurement of Fiber Cross-sectional Area

Of the several schemes undertaken to obtain an accurate measure of fiber cross-sectional area, optical measurements at the point of failure proved to be the most suitable. Preliminary attempts included measurement of average wall thickness and fiber cross-sectional dimensions both on the end-grain surface of the wood before pulping and of individual fibers while in solution after pulping. Both methods demonstrated that, although a fiber may appear to be of uniform cross-sectional dimensions, close examination reveals moderate fluctuation of wall thickness, and tangential and radial dimensions along its length. In order to calculate accurate values of tensile strength, a measure of fiber cross-sectional area at the point of failure was needed. The method used was basically the same as that reported by Van den Akker, *et al.* (*12*).

After completion of a tension test, one segment of the broken fiber was removed from the grips using the tweezers for facility in handling and to avoid inflicting any damage to the fiber. The fiber was mounted along the edge of a 1 by 3-in. glass slide with the broken end projecting upward from the plane of the surface of the slide. The technique permitted mounting of fibers of a given species or type in the order of testing; they could be measured immediately, or stored for examination at a later date. Using an ordinary microscope the broken end of each fiber was brought into focus while viewing the fiber end on. Nearly every fiber was collapsed at the time of measurement and appeared as a dark area in the field of the

Fig. 2. A latewood fiber of cypress in place for testing. A common straight pin is included at the right.

Table I. Mechanical Properties of White Spruce, Cypress, and Douglas-fir Fibers

	Cross-sectional area sq. in. × 10^{-6}	Tensile strength, lb. per sq. in.	Young's modulus, lb. per sq. in. × 10^{-6}	Strain at failure, in. per in.	Work to failure, in. lb. per cu. in.	Proportional limit stress, lb. per sq. in.
White Spruce earlywood fibers						
Average	0.318	75,900	3.658	0.0245	970	42,700
Range	0.191–0.528	64,400–88,100	2.060–4.820	0.0138–0.0400	664–1399	30,700–62,900
White Spruce latewood fibers						
Average	0.454	82,500	5.085	0.0192	780	57,600
Range	0.213–0.755	74,200–95,300	2.960–8.620	0.0091–0.0280	271–1052	42,100–75,600
Cypress earlywood fibers						
Average	0.448	80,000	2.599	0.0341	1354	42,300
Range	0.234–0.617	109,500–66,100	1.655–3.650	0.0260–0.0495	1018–2022	31,600–58,500
Cypress latewood fibers						
Average	0.708	143,900	5.213	0.0324	2296	73,400
Range	0.362–1.180	117,700–186,300	2.830–8.640	0.0253–0.0426	1890–2680	40,300–101,500
Douglas-fir earlywood fibers						
Average	0.550	49,850	2.577	0.0208	549	.....
Range	0.383–0.766	42,400–57,600	1.680–4.770	0.0112–0.0272	299–768	.....
Douglas-fir latewood fibers						
Average	0.817	138,000	6.184	0.0245	1675	48,900
Range	0.616–1.382	113,900–182,500	4.060–9.550	0.0117–0.0352	619–3210	31,900–102,100

microscope. The cross-sectional area of each fiber was measured using a calibrated micrometer eyepiece. At a total magnification of 1000× the cross-sectional area of each fiber could be estimated to ± 0.01 × 10^{-6} sq. in. The measurements were carried out at a temperature of 72°F. and relative humidity of 50 ± 2%.

RESULTS

Using the plot of the load over deformation, Young's modulus, tensile strength, stress at proportional limit, deformation at failure, and work to failure were computed for each fiber. Young's modulus was computed as the ratio of stress to strain over the linear portion of the load-deformation plot, tensile strength as load at failure divided by cross-sectional area of the fiber at the point of failure, work to failure as the area under the load-deformation plot divided by the volume of the fiber, and proportional limit stress as load at proportional limit divided by the cross-sectional area at the point of failure. Average values and the range of the ten fibers of both early and latewood of each species are recorded in Table I. Not every fiber exhibited a proportional limit, particularly the earlywood fibers of Douglas-fir. As a result, some of the average values recorded in Table I are based on less than ten but no fewer than seven tests.

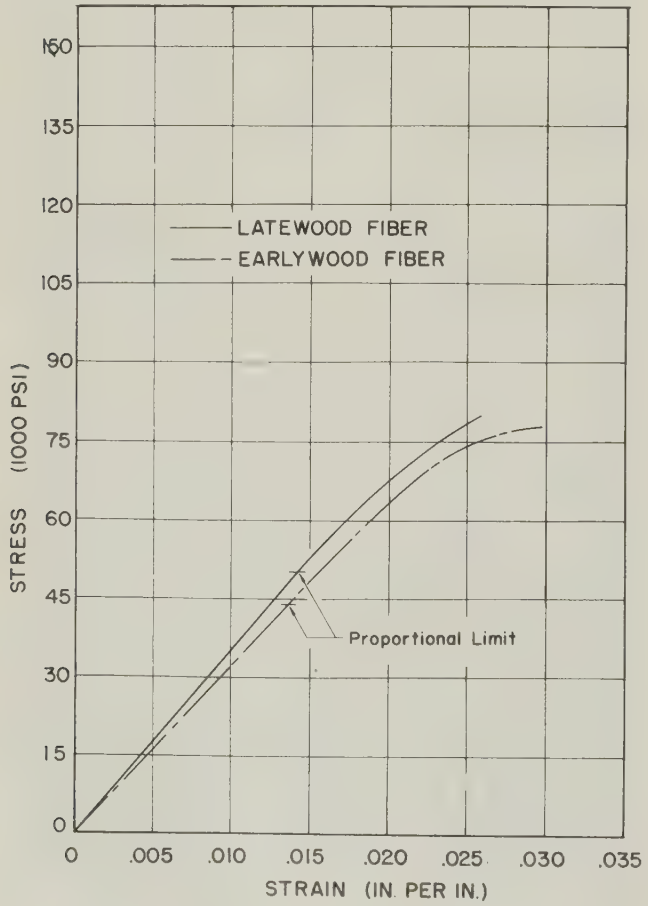

Fig. 3. The relationship between stress and strain for a typical early and latewood fiber of white spruce

An accurate interpretation of the data in Table I as well as the succeeding figures must recognize that all mechanical properties are based on either the cross-sectional area of the fiber at the point of failure or its total volume. Hence, specific gravity has been eliminated as an influence on properties; the molecular configuration remains as the dominant physical property of the fiber governing the observed characteristics.

The data of Table I show that the tensile strength and Young's modulus of latewood fibers of white spruce possess slightly higher average and range values than the earlywood fibers of the same species. This difference is also demonstrated by the load-deformation plots in Fig. 3 where the latewood fiber possesses a steeper slope as well as a higher stress at failure. On the other hand, as shown by the values of work to failure in Table I and the areas under the curves of Fig. 3 earlywood fibers of white spruce can absorb a slightly greater amount of total energy than latewood fibers. The proportional limit stress of both early and latewood fibers was limited to a range of 60 to 70% of the tensile strength. Earlywood fibers of white spruce ranged from 0.161 to 0.185 in. in length and latewood fibers ranged from 0.161 to 0.191 in.

All values for mechanical properties of latewood fibers of cypress proved to be higher than those of the earlywood fibers. It is interesting to note, however, that the average strain at failure of both types of fiber was nearly the same (Table I). As a result, differences in work to failure of early as compared to latewood fibers must be ascribed to the greater tensile strength of the latter. For these fibers the average stress at

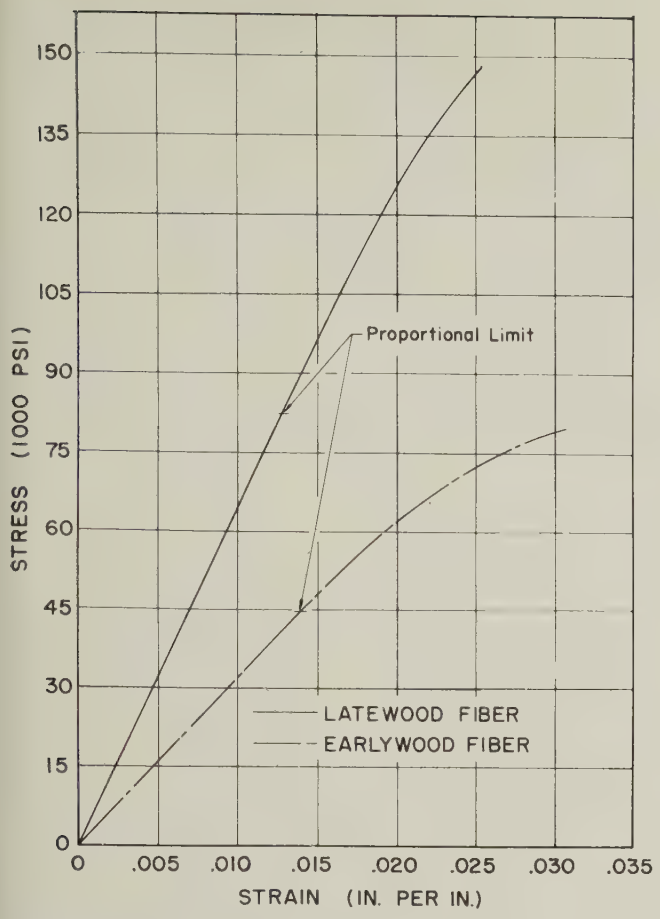

Fig. 4. The relationship between stress and strain for a typical early and latewood fiber of cypress

proportional limit proved to be approximately 50% of the failing stress. Stress-strain plots of a typical early and latewood fiber of cypress are shown in Fig. 4. Earlywood fibers ranged in length from 0.158 to 0.201 in. and latewood fibers from 0.232 to 0.252 in.

The data collected from fibers of Douglas-fir indicate a more marked contrast between early and latewood than was noted with either white spruce or cypress. The average tensile strength of the earlywood fibers of this species proved to be less than one-half that of latewood fibers, while Young's modulus and work to failure of the earlywood fibers were virtually one-third comparable values of latewood fibers. However, as was noted from the cypress data, the extensions at failure of both types of Douglas-fir fiber were more nearly equal than other mechanical properties. Of even greater interest is the lack of a limit of proportionality in the relationship between stress and strain in the earlywood fibers of Douglas-fir (Table I and Fig. 5). In length, earlywood fibers of Douglas-fir ranged from 0.165 to 0.272 in., and latewood fibers ranged from 0.224 to 0.244 in.

Stress-strain diagrams of earlywood and latewood fibers of the three species tested are shown in Figs. 6 and 7, respectively. Each relationship was plotted from the average data recorded in Table I. The curvilinear portion of each was estimated from the curves of the fibers it represents.

The appearance of a proportional limit in a load-deformation test is evidence that the fiber possesses a viscoelastic rather than simple elastic nature. Its mechanical properties are time dependent. Under conditions of static strain, relaxation of stress would be expected, and under conditions of static stress, continuing deformation, commonly termed creep, would occur. It follows, therefore, that the value of the proportional limit relative to maximum strength will be dependent on the elapsed time of the load-deformation test. A test conducted over a period of a few seconds may exhibit linearity to failure whereas a test conducted over a longer period of time, say several hours, will probably exhibit curvilinearity from zero to failure. The linearity of the load-deformation diagram for earlywood fibers of Douglas-fir is tentative evidence of a relatively low amount of creep in these fibers.

The range of test values exhibited by the ten fibers of each type can be ascribed primarily to two broad sources of variation; differences in the physical structure of the fibers and experimental error. Fluctuations of the cross-sectional area of a fiber along its length and dissimilarities in the minute structure of the cell wall can lead to the concentration of stress in localized area, premature failure, and apparent differences in the strain behavior of fibers. It should also be pointed out that values of Young's modulus were computed assuming a uniform cross-sectional area along the length of the fiber equal to the area at the point of failure. Since the dimensions were not uniform and the cross-sectional area at the zone of failure may very well be the minimum of the fiber between the grips, it is highly probable that calculated values of Young's modulus are slightly in excess of those that the fibers actually possess. Deflection of various components of

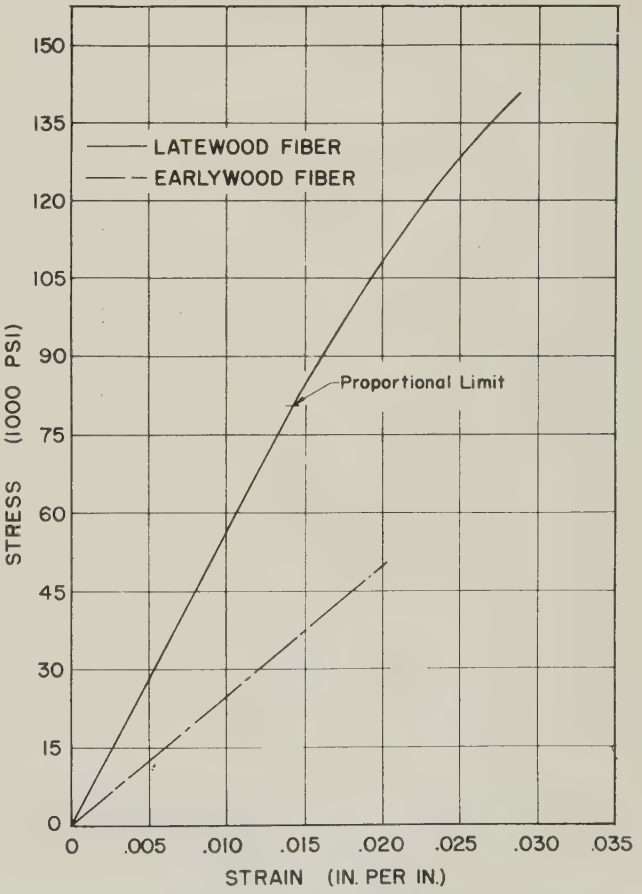

Fig. 5. The relationship between stress and strain for a typical early and latewood fiber of Douglas-fir

the testing apparatus were taken into account before calculation of mechanical properties and was eliminated as a source of error. Calibration of the load weighing system of the apparatus was undertaken at frequent intervals during testing to eliminate an additional potential source of error.

The method of gripping and the near tubular shape of the fiber contribute to a concentration of tensile stress in cross sections of the fiber in the immediate vicinity of the grips. Furthermore, since a fiber is characterized by a gradual reduction in cross-sectional area from the center to the ends it is normal to expect slightly higher stresses at the ends as compared to the center. Of the fibers tested 55% failed at a grip and the remaining 45% failed within the center one-half of the fiber between the grips. It is assumed, therefore, that stress concentrations, though they undoubtedly exist, are not of sufficient magnitude to materially influence the mechanical properties of wood fiber in tension.

CONCLUSIONS

Measurement of the mechanical properties of papermaking fiber is entirely possible providing that care is taken in the preparation and handling of fibers and in the interpretation of test data. The data presented for fibers of three native coniferous species demonstrate vast differences that exist between fibers of different species and between early- and latewood of a single species. These differences are probably due to variation in the elementary molecular structure of the fibers.

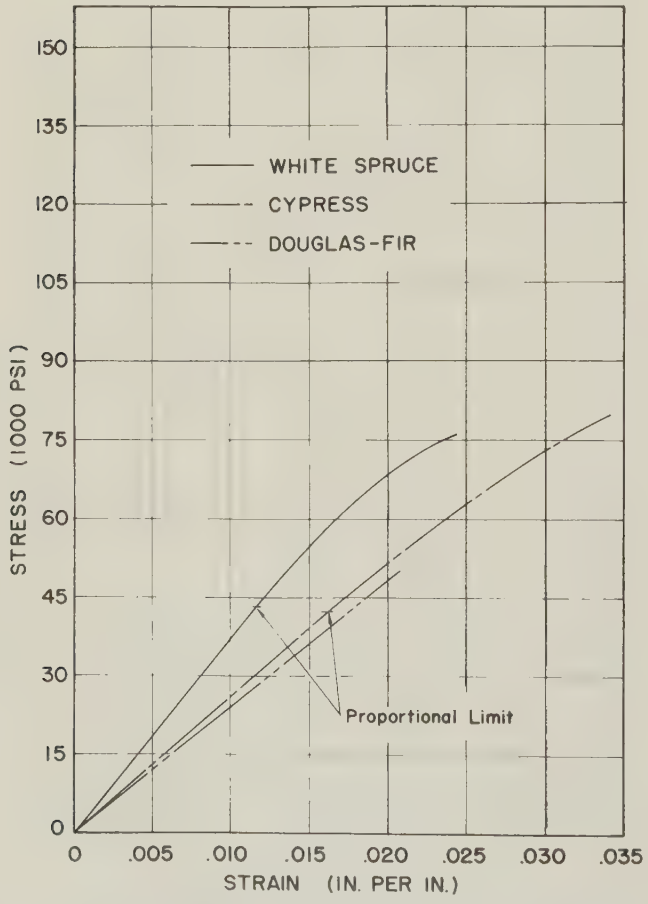

Fig. 6. Average stress-strain relationships for earlywood fibers of white spruce, cypress, and Douglas-fir

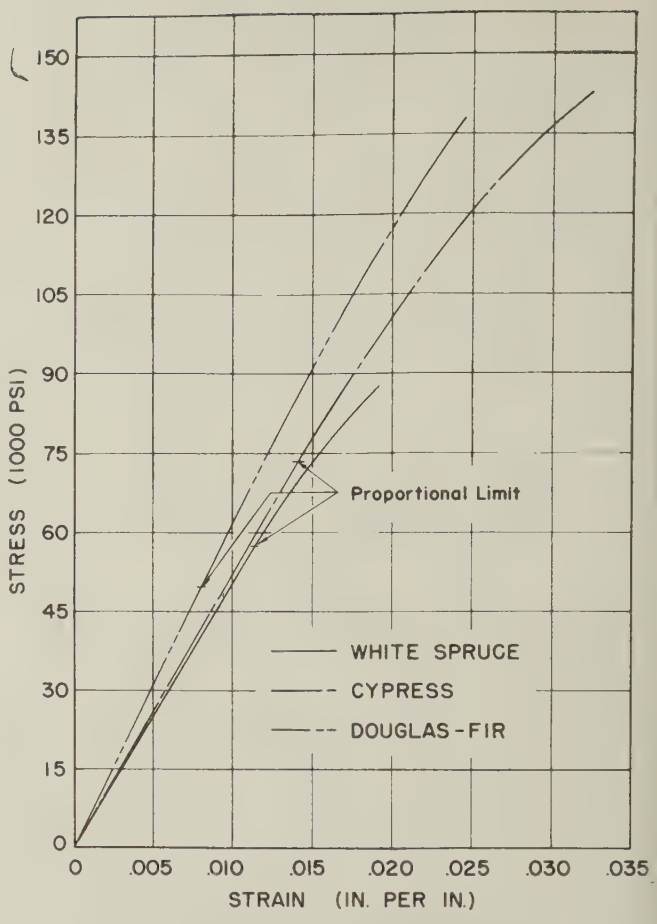

Fig. 7. Average stress-strain relationships for latewood fibers of white spruce, cypress, and Douglas-fir

Testing was restricted to the relationship between load and deformation which demonstrated the existence of a limit in the proportionality of stress to strain. The existence of this limit implies the presence of a viscous as well as an elastic nature in wood fiber. Recognition of the viscoelastic nature of the fiber suggests the need for study of the properties under conditions of static strain for measurements of the stress-time function, under conditions of static stress for evaluation of the strain-time relationship, and also under dynamic conditions in order to cover a relatively broad region of the time scale.

Differences in the mechanical properties of early- and latewood emphasizes the need for a better understanding of environmental and genetical factors which govern the relative percentages of these two annual-ring components. It is emphasized that recognition of this inherent difference between fibers should not be restricted to strength alone but must include the entire spectrum of fiber mechanical properties. It is entirely conceivable that differences of mechanical properties can exist between fibers of a single species or type as a result of environment or heredity. A knowledge of the influence of factors within the sphere of these two broad categories is paramount to more efficient production of usable fiber.

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Evolutionary Operation in Chemical Processes

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The first requirement of a chemical plant is that it shall maintain production. However, it is axiomatic that the plant operation is not optimum without some experimentation. The effectiveness of individual experiments is limited by the necessary restriction of maintenance of production and the consequent requirement of very small changes in variables. Thus, a situation is automatically established whereby small effects are studied in the presence of relatively large amounts of "noise," the latter generated by uncontrollable process variation. Evolutionary operation is a system of integrated experiments involving only small variable changes. It is designed first to sharpen the distinction between changes produced by variables and those resulting from noise, and second to allow a number of variables to be studied concurrently. At no time does it interfere with normal operation. It is, then, a method whereby the plant is run to produce, coincidentally, product and information. The calculations of the results are not extensive or complicated. The decisions regarding desirable process changes are made by the plant personnel, not the statistician. The elements of this system which is already highly successful both in this country and abroad, are described. Illustrative data are presented.

Mathematical methods and concepts involved in statistical theory date back to the 18th century. However, small number statistics, with consequent applicability to experimental work, began with the Student *t*-test (Gossett) in 1908. The next important contributions to this field were attributable to Fisher, to whom we owe much of the current knowledge of analysis of variance. His publications began in 1925. The first big impetus toward the use of statistics in industry resulted from the development by Shewhart of statistical quality control (SQC). Although this application originated in the 30's, its first large use was during World War II, particularly in the mechanical industry.

Basically, it seems distressing that the chemical industry was so late in profiting from these fundamental advances in experimental and plant methods. However, it was not without reason. The work of Gossett and Fisher was largely concerned with the fields of agriculture and biology. Translation of their experimental designs to the chemistry field was never easy, and some of them were completely inapplicable without considerable further development. The bulk of chemical industry does not turn out discrete units, an ideal situation for SQC; moreover, while control is important, optimization of the chemical process is, in many cases, a much more important issue.

Today, the chemical industry is well aware of the benefits to be gained from statistical applications, to both experimental and plant problems. Advances in theory and techniques are credited to many statisticians, but, in the chemical field, no one stands out as clearly as Box, with a variety of co-workers. I propose to discuss here his system of optimization of processes and plants, generally known as evolutionary operation (EVOP). As will become apparent, this system becomes one of continuing operation, and thus parallels very closely the practice of statistical quality control. As with SQC it has the objective of keeping the process in line and telling when it gets out of line. However EVOP does even more—it tells which way to go to effect corrections.

It is axiomatic that no plant operates at optimum conditions unless it has been subjected to some systematic program of controlled plant runs. To support such a dogmatic statement look at both new and old plants. First take the new plant. Unless there are absolutely no holes in process and equipment theories the scale-up from process development to the actual plant will not result in the same optimum conditions as those experienced in development work. This situation may be illustrated in Fig. 1 where the coordinates are the process variables and the contours are lines of constant response. The characteristic plant response surface will be similar to that encountered in process development although mildly distorted and displaced. There is, then, no way of bringing the process to optimum plant conditions except by systematic study of the plant itself. In contrast to the new plant, it might seem that the operating personnel would surely have brought an established process to its optimum. There is no doubt that intelligent attempts have been crowned with many successes. However, many indeterminate results and many failures have also been encountered because the results of any program are bound to be partially obscured by " noise" introduced by uncontrolled or uncontrollable sources of variation.

Evolutionary operation, subsequently referred to as EVOP, is an attempt to circumvent the "noise problem." It is based upon the principle that time is not

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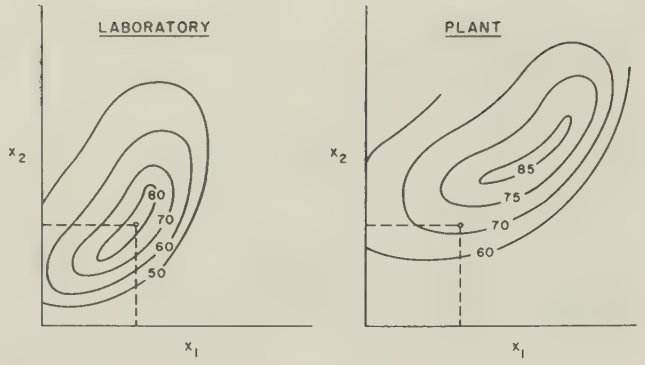


Fig. 1. Response surfaces: plant versus process development

of the essence. In development there is a tremendous premium on a minimum number of runs, due both to time and expenditure for a nonproductive operation. In the plant there is no restriction on the number of runs. Since the plant is operating for product it may as well coincidentally produce useful information. For the same reason there is substantially no limit on time, although one naturally hopes to reach the optimum as soon as possible.

But there is one primary requisite in any programming of plant runs: don't disturb production. This is the mandate under which EVOP operates.

The subsequent description of EVOP will be concerned with the following subjects: (1) inviolate conditions; (2) a suitable design; (3) presentation of the data; (4) interpretation of the data; (5) method of calculated information; (6) a few representative problems which may be encountered.

INVIOLATE CONDITIONS

Consider a program of plant operation in which distinct changes are made in some or all of the controllable variables. The results of this program are evaluated in terms of some response, preferably dollars, which should be optimized. The ideal situation would be shown in Fig. 2. At the top there is shown a constant response for a given set of variable conditions followed by a jump in the response as the conditions are changed and followed again by a return to the original variables and original response. Unfortunately, the results which are obtained from a real program are much more like those in the second part of the figure in which the same pattern exists but is covered completely by the confusion of random error. There are two ways to remedy this. The first is shown in the third part of the figure where the amount by which the variables are changed is markedly increased so that the change in response will be much greater and can be seen even in the presence of the same amount of noise. However, production personnel would correctly object to this method of clarification for the amount of change of variable required would undoubtedly result in some operation which would materially reduce the quantity or the quality of the product. The only satisfactory way is to retain the original small amount of change in the response and then to reduce the amount of noise until the change in response is clearly indicated as shown in the last part of the figure. This is the job that EVOP must perform.

In a summary of this length it must be assumed that the reader has sufficient knowledge of statistical experimentation to understand the role of replication in reducing experimental error. Repeated experiments will, in general, improve the estimate of the mean response, improve the estimate of the amount of noise, effectively reduce the noise in proportion to the square root of the number of experiments performed, and therefore allow a better estimation of the range in which the true response may lie with given probability.

There is no guarantee that the number of runs required to clarify a program in this fashion may not be large. While the cost of such a program in research or development might be prohibitive there is no such danger in the plant. It is running for product; it is now also going to run for information.

A SUITABLE DESIGN

At this point it is worth while to consider the design of the program which should transform a plant from its current mode into a position at the bottom of the cost valley which might be represented by the contour map of Fig. 1. This response surface is undoubtedly highly curved and may be somewhat complex in shape. An experimental program which would completely evaluate such a surface might also be fairly complex. But advantage may be taken of the fact that only small changes can be tolerated in the plant. Therefore, any

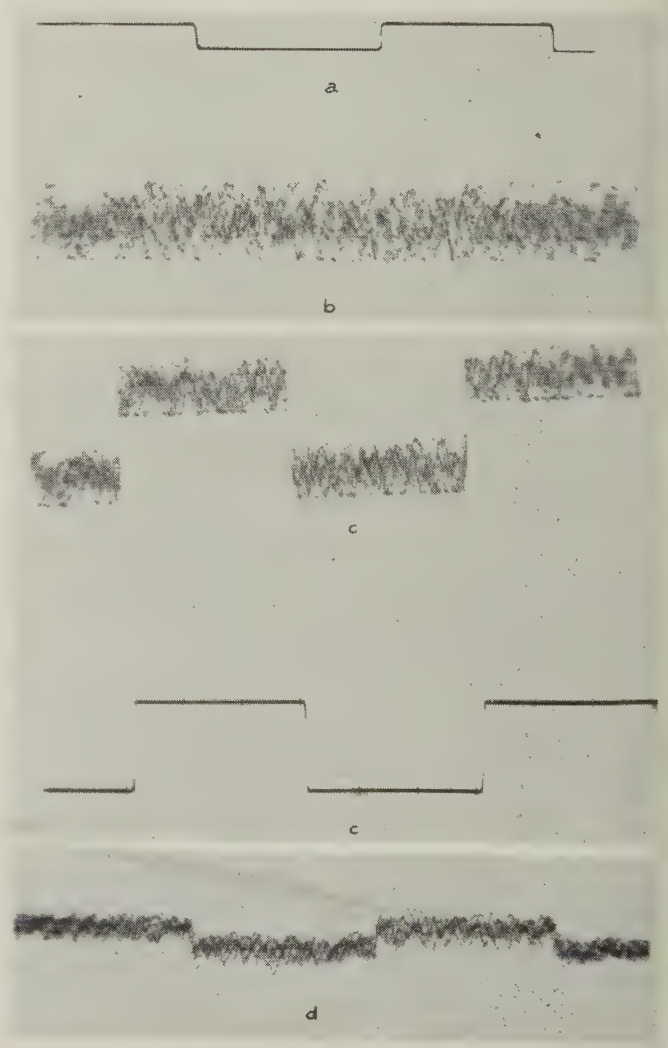


Fig. 2. Oscilloscope analogs to process changes with experimental error ("noise") present

region in which a program is being conducted must necessarily be a small part of the entire surface and can undoubtedly be considered to be locally linear, or planar, at least to a reasonable first approximation. Therefore, programs which consider only first order effects are quite acceptable; such programs require that each variable shall be studied at only two levels, one high and one low. Those familiar with statistical designs will recognize all subsequent programs as being of this two-level factorial form or a fractional replicate thereof. For the purposes of illustration only two variables will be controlled, a limitation for the purposes of representation rather than one inherent to the system. Greater numbers will be considered later.

Consider a process in which it is desired to study temperature and the concentration of an entering raw material, as in Fig. 3. Here the extent to which the plant personnel has judged it reasonable to change these variables without disturbing production has dictated a total 4° change in temperature and a total 1% change in concentration. The primary experiments in a two-level factorial would be those at the corners of the square representing these limits. The center of the diagram is current plant practice. This diagram represents nothing except the points at which runs will be conducted.

Assume that the runs are undertaken in the order listed: 1, 2, 3, 4, 5. After these five runs have been completed, the results are studied to see whether there are any indications of a desirable change in concentration or in temperature. Assuming the normal situation, where real effects are covered by contributions from poorly controlled variables and from plain experimental error, no conclusions should be drawn at this point. Replication now begins. Five more runs are conducted in the same order. The results of the two replications (10 runs) are now being studied to see whether there exist indications of desirable changes in the plant operation. Assuming that, again it is impossible to draw conclusions with confidence, the entire program is again repeated, and so on until decisions may be made as to what should be done with the process. It is now important to determine how to arrive at these decisions. A list of alternate decisions is discussed later.

PRESENTATION OF DATA

First is the method of presenting the data for best interpretation. A summary form is suggested in Fig. 4. There are a number of important features of this diagram. A most important item is the pattern of runs. Therefore this "information board" displays the variables studied, with conditions for each run marked. Next is noted phase and cycle. Phase 3 means that two previous phases of experimentation are

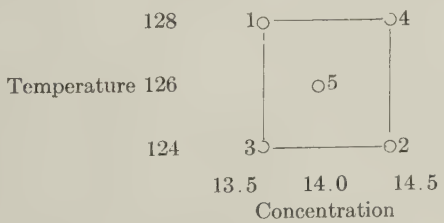
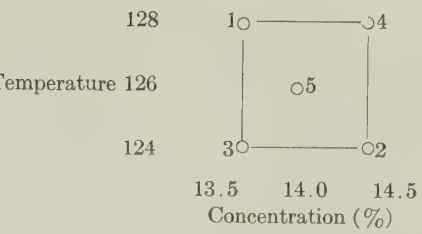


Fig. 3. Basic design

complete. A first phase was completed and a shift in process conditions was suggested. This shift was effected and a further program (phase 2) was run suggesting a still further shift. That shift having been made the program is now in phase 3. Cycle 16 indicates that the phase 3 program of five runs per cycle has been completed 16 times (i. e., 80 complete runs).



Phase 3 Last cycle completed 16

	Cost	Impurity, %	Fluidity
Requirement	Minimum	Less than 0.50	Between 55 and 80
Running averages	32.6 33.9 32.8 32.3 33.4	0.29 0.35 0.27 0.17 0.19	73.2 76.2 71.3 60.2 67.6
Effects with 95% error limits			
Conc.	1.1 ± 0.7	0.04 ± 0.03	5.2 ± 1.1
Temp.	0.4 ± 0.7	0.14 ± 0.03	10.8 ± 1.1
C × T	0.1 ± 0.7	0.02 ± 0.03	−2.2 ± 1.1
Change in mean	0.2 ± 0.6	−0.02 ± 0.03	−1.6 ± 1.0

Fig. 4. Information board

The next item is the list of responses which are to be studied. It is rare that there is only one of importance. There is one of main importance, and it can generally be stated to be surely one involving dollars. But, there will undoubtedly be quality measures which are also essential, in this example, impurity and fluidity. On the following line the requirement for each of these responses is listed. Obviously cost should be a minimum. Also obviously the amount of impurity should not be a minimum but should merely be limited so that it should not rise above the specification limit. The fluidity must be contained within a given range. The only way in which one can keep clearly in mind all the objectives of the program is to list the requirements for each of the responses.

The next line contains a summary of the information obtained to date. Each figure under each response represents the average of the 16 runs. These are the data which will be used to interpret the results of the experiment and to decide whether or not a change in process conditions is indicated. The remainder of this figure provides the information on which the decisions are made. There are four items: (1) the effect of temperature, (2) the effect of concentration, (3) the effect of their interaction, and (4) the change in the mean. To dismiss the last two rather rapidly, they are both present as an aid in assessing the adequacy of the original conclusion that the surface within the limited region would be planar. If such an assumption turns out to be unjustified, the interpretations are no different from the simple case but somewhat more complicated.

INTERPRETATION OF RESULTS

Two figures are listed for each effect estimated. The effect of concentration is 1.1 with the additional information that this figure is good to ±0.7. In statistical terminology these two figures are respectively the best estimate and the confidence limits, in this case 95% con-

fidence limits. Combined, they state that unit increase of the concentration will increase the cost by 1.1 ± 0.7 units. Thus it would be correct to state that there is a 95% chance that the effect of concentration is something between 0.4 and 1.8 with the best estimate at 1.1. It seems quite clear that a decrease in concentration will decrease the cost.

In contrast, the temperature effect states the following. There is a 95% chance that an increase in temperature will increase the cost by something between −0.3 units and +1.1 units, with the best estimate at 0.4. However, in this case one of the possible values for temperature is zero. Under these circumstances one would not want to draw a definite conclusion that there is any strong effect of temperature.

Therefore, with respect to costs, a decrease in concentration seems clearly desirable and no change of temperature appears to be helpful. However, before a change is made in the process it is necessary to look at the qualifying responses. An increase in concentration will increase the fluidity. The contemplated decrease may bring the process into a range in which the minimum of 55 may be attained. Therefore, this response must be watched closely as the concentration is decreased. Moreover, a decrease in temperature will sharply decrease the fluidity. If one has been tempted to take advantage of the rather uncertain small decrease in cost which *might* accompany a decrease in temperature, one is almost certain to run into difficulty with the fluidity. The decision to leave temperature unchanged in future runs is, therefore, supported by the qualitative response. With respect to impurity, decrease in either temperature or concentration would appear to decrease the impurity, a desirable effect. In this particular program it was finally concluded that a reduction in concentration is desirable and this one variable was studied in a new design of plant runs, phase 4.

Since this information should be directly available to the process supervisor, this so-called information board should be located in his office. New information is entered as obtained complete with calculated effects and confidence limits.

Some remarks about the confidence limits are clearly desirable before leaving the subject of interpretation. The 95% probability level chosen will be true if none of the assumptions underlying confidence limits are violated. However, whether true or not, there is nothing magic about 95%. One man may want to make his statement with 95% probability of being right, another may want to work at 70%; the most conservative may even choose 99%. Any probability level can be chosen and calculated. More important, however, is the fact that these confidence limits do not constitute any kind of *rule*. They are merely a *guide*. For example, the effect of temperature was not truly conclusive at the 95% limits but would be quite impressive if the limits chosen were 80%. If there had not been strongly undesirable effects in fluidity for a decrease in temperature it is probable that the process supervisor would have decided to try reduction of the temperature. In other words he looked at the data and could say, "I cannot be sure that there is a real effect of temperature but if I reduce it a little bit it won't hurt anything," then he would have concluded, "I think that I will take that chance for the sake of the benefit which *may* accrue." In this particular case he could not arrive at such conclusion because of the fact that he could see that such a change would adversely effect the fluidity. The important point is that the confidence limits are guides, not rules, and absolute levels of probability are relatively unimportant. The confidence limits allow the assessment of the value of an effect *relative to* the confusion introduced by *process variability*.

CALCULATIONS

There are two main calculations required: first the effects of each variable; and second, confidence limits. Both are based upon linear combinations. Therefore consider the linear combination

$$w = a_1x_1 + a_2x_2 + \ldots\ldots\ldots\ldots\ldots a_nx_n.$$

where

a_i = an arbitrary numerical coefficient, and
x_i = a value of a variable

The average effect is

$$\mu_w = \sum_{i=1}^{n} a_i\mu_i$$

where μ is the population mean, and the variance of this linear combination is

$$\sigma_w^2 = \sum_{i=1}^{n} a_i^2\,\sigma_i^2$$

where Z^2 is the population variance.

A calculated effect, such as the effect of temperature or concentration, is a linear combination of the five runs in the basic pattern. For example, take the effect of concentration. One wishes to know whether the two runs at the high level of concentration produce a greater cost than the two at the lower level. One method of assessing this effect is

$$\frac{1}{2}(x_2 + x_4 - x_1 - x_3)$$

This estimated effect is the average difference from high level to low. Some prefer the effect for a unit change and, instead of averaging the high and low values and taking their difference as shown, divide by the number of experiments in the exterior of the design (i. e., omitting the center point). Table I gives these alternatives for two-variables and three-variable patterns and also indicates alternate methods of estimating the effect of change in the mean. This last estimates the curvature of the surface, for if the local surface investigated is truly planar the average of the external points exactly equals the internal points. Therefore, if one adds the four external points and subtracts four times the internal points one obtains a positive value for a surface concave upward and a negative one for a surface concave downward. In the case of cost, one would expect it to be concave upward but the curvature may be so slight as to be inconclusive, as in the example. The $C \times T$, or interaction, also estimates curvature since it is also second order. It is obtained by comparing values on the two diagonals. When curvature is clearly evident the exact character of the curvature must be determined before a directional move is made.

Process variability offers opportunity for an extremely interesting analysis of the data. If there were

Table I

	Design $2^2 + 1$	Design $2^3 + 2$
Average effect:		
$\frac{1}{2}$ [Σ (high) − Σ (low)]	σ^2	$2\sigma^2$
Unit effect:		
$\frac{1}{2^k}$ [Σ (high) − Σ (low)]	$\sigma^2/2$	σ^2
Change in mean:		
$\frac{1}{5}\left(\sum_{i=1}^{4} Y_i - 4Y_c\right)$	$\frac{4}{5}\sigma^2$	..
$\frac{1}{4}\sum_{i=1}^{4} Y_i - Y_c$	$\frac{5}{4}\sigma^2$	..
$\frac{1}{10}\left(\sum_{i=1}^{8} Y_i - 4\sum_{c=1}^{2} Y_c\right)$	..	$\frac{2}{5}\sigma^2$
$\frac{1}{8}\sum_{i=1}^{8} Y_i - \frac{1}{2}\sum_{c=1}^{2} Y_c$	..	$\frac{5}{8}\sigma^2$

σ^2 = estimate of error variance
Y_c = a center point response value
Y_i = an external point response value

no shift in the process from one cycle of five runs to the next and if there were no experimental error, then the subtraction of the latest response value from the average of all previous responses at the same point (e. g., the response at point 2 from the average of all previous responses at point 2) would always be zero. If there is a shift of process average then the differences obtained by this calculation at each point should be the same; they are, in fact, not identical. Their variation can only be the result of the process variability inherent in the program. Therefore, the variability in these differences can be used to estimate the process variability. This system has the advantage that, if there are block effects (from one series of five runs to the next series of five runs) then the calculated experimental error will not include this block effect.

The method suggested for estimating process variance uses the range, R, of the values Δ_i in any cycle. It is easy to calculate since it is defined as the highest minus the lowest value. Further for small sample size, as is always the case with EVOP (5 points in the example and not over 10 in the case of a three or four factor experiment) it is quite efficient. Range is converted to s, the estimate of the variance of Δ through a constant, a few values of which are tabulated in Table II.

The procedure is illustrated in Table III. Note that

Table II

Sample size, k	f_n	*Efficiency*
4	0.486	0.975
5	0.430	0.955
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.		
8	0.351	0.890
9	0.337	0.869
10	0.325	0.850

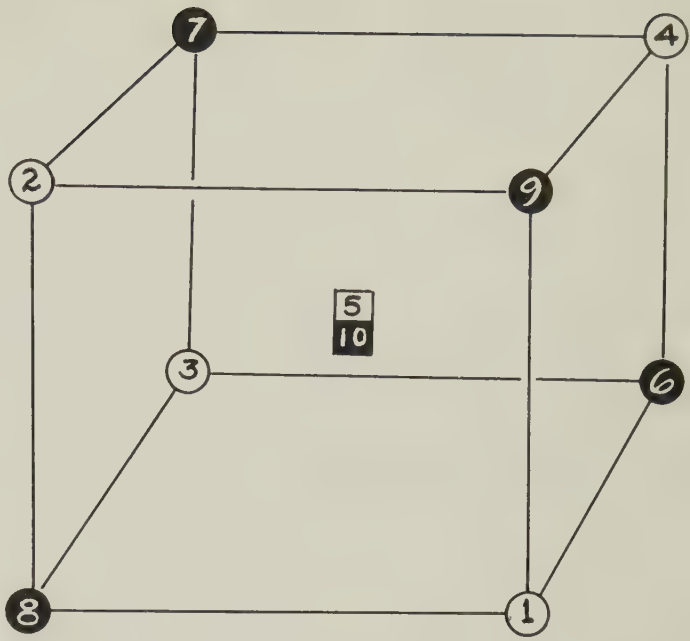

Fig. 5. Diagrammatic representation of first order designs for three and four variables

the variance of the difference is not process variability because Δ_i is obtained from a linear combination. The $n - 1/n$ factor occurs in conversion of the variance of the linear combination to the variance of the experimental measurement.

An estimate of experimental errors is obtained each time a series of runs is made. It would be wasteful to throw away all the preceding information and use only the latest. Therefore, at the end of each series of runs the estimates from previous runs are pooled with the estimates from this one run. Two methods are suggested, that of pooling sums of squares, and that of using the average range. While the former may be more correct statistically, it is much more of a nuisance in its requirement of squares and square roots. The average range requires only addition, subtraction, and division. The average range method can therefore be

Table III. Calculation of σ^2

k = experiments per cycle
n = cycles completed
$\Delta_i = Y_i - \bar{Y}_{i,n-1}$; $i = 1,2, \ldots, k$
R = range of Δ_i
s = estimate of $\sigma = \hat{\sigma}$
f_n = factor for converting R_n to s_Δ

$$\sigma_\Delta^2 = \frac{n}{n-1}\sigma^2, \text{ by linear combination}$$

$$s_n = \sqrt{\frac{n-1}{n}}\, R_n f_n$$

and

$$s = s_p = \sqrt{\frac{s_{n-1}^2(k-1)(n-2) + s_n^2(k-1)}{(k-1)(n-1)}}$$

or

$$s = \sqrt{\frac{n-1}{n}}\, \bar{R} f_n$$

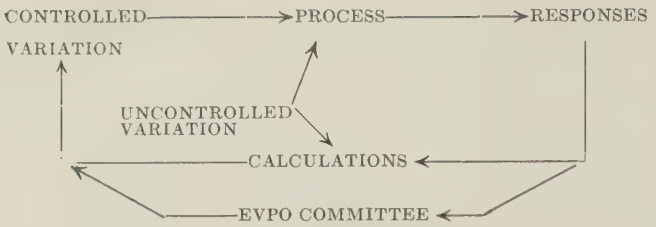

Fig. 6. Flow sheet

much more easily handled in the plant where the calculation should be made.

Confidence limits are obtained from the estimate of experimental error by dividing by the square root of n, the number of cycles completed and multiplying by a constant typical of the probability level desired. The multiplying constant is the value of student-t for the number of degrees of freedom. This number of degrees of freedom is $k - 1$, for each cycle, 4 in the present example, and therefore four times the number of cycles. Obviously, the value of t changes as one progresses through the series of cycles. However, with the confidence limit as a guide instead of an absolute rule there seems to be little harm in using a constant value of t; a reasonable one would be 2, the 95% value after a fair number of degrees of freedom have been obtained. This use of a constant value of t in order to simplify the calculations has been adopted in at least one plant.

The organization and operation of EVOP is summarized in Fig. 6. The only feature of this flow sheet not already discussed is the EVOP Committee. This committee is composed of representatives of all groups in the plant with special knowledge of the process, as for example, the analytical chemists, the group responsible for its development, the sales force, the statisticians, the design engineers. The chairman is the process supervisor. This committee operates in purely advisory fashion, meeting infrequently to discuss progress to date and suggest new lines for the future. Possibilities for new products, new qualities, new processes thus feed back into the company while a stream of ideas for the improvement of the existing process flows to the unit.

GENERAL REMARKS

The Number of Variables

The number of variables which can be investigated in an EVOP program varies from one to four. The most popular numbers are two and three, the experimental design for the latter being represented in Fig. 5. This design will incorporate an experiment at each corner of the cube and preferably two center points. However, since one is interested only in first-order effects it is not necessary to run more than four of the external points in order to obtain estimates of the three linear main effects. One can choose either the black points or the open points for a consistent set of experiments, recognizable as half replicates of the ordinary 2^3. For a four-factor experiment, the entire cube should be run, with the black points representing one level of the fourth variable and the open ones the other level of the fourth variable. The center points will of course be at the zero level of this fourth variable as they are at the zero level of the other three variables.

With more than four variables to investigate in an EVOP program, run consecutive programs. First select the two, three, or four most important, in the opinion of all concerned with the process. After all improvement has been made which can be obtained from these, shift to another set of variables. New variables are added in new programs until the entire set of interesting variables has been covered. Although there may be factor dependencies, or interactions, which have been missed because of the failure to include the two variables in one program, this omission need not be a source of alarm; it is perfectly possible to rerun new programs with different combinations of the variables. An appreciable period of plant operation under the EVOP scheme is thus suggested. In fact EVOP may be continuously maintained as a control, in much the manner of quality control for a mechanical product.

The Correct Response

Earlier remarks indicated that the main response should be in dollars. Of this there can be no question. The only thing which is to be optimized in all operations is dollars. However, in establishing this response as the major one, qualifying responses which assure the maintenance of proper quality must always be included. The number of the qualifying responses cannot be predicted. This is a matter to be decided in each individual case and is one which may well involve the sales force. A member of the sales force on the advisory committee is therefore a very reasonable assignment.

It is obvious that one does not obtain the figure of dollars directly from the experimental program. Some more natural responses, like yield, per cent conversion, or productivity will be directly obtained. Do not be misled into their use by their simplicity or availability. Go to the trouble of evaluating the cost function, measure all of the necessary responses involved, and calculate the main response as dollars.

As an example of the errors that can be encountered by the use of wrong response consider the case where cost per pound was used. The estimated improvement for a one unit change in the desired direction was $75,000 per year. Unfortunately, in the process being considered this amount of improvement was extremely small. However, it did not take into account the increase in production. When this improvement was included in a straight dollars response, the improvement was not $75,000 per year but $300,000, a well worth-while saving.

Use of Existing Data

Use of existing data in establishing an EVOP program is frequently suggested. Naturally such data are useful. One never wishes to throw away information simply because it was not obtained on the type of program which one intends to run. Existing information may provide an initial estimate of the process variability. With such an estimate it is possible to investigate the changes at the end of the first cycle. Without it all that is available at the end of the first cycle is the estimate of the effects with no estimate of the confidence limits; it is then impossible to draw conclusions as to the importance of the effects.

However, in recommending use of existing data, one must bear in mind that the new response is dollars and that old responses may not have been. Since the estimation of the variance of functions is approximate at best, and since important conclusions are not expected at the end of the first cycle, the problem becomes nearly academic.

Magnitude and Direction of a Move

When the effect of a variable is believed to be significant, its magnitude tells the amount of improvement in response to be expected for unit change in the variable. When more than one is significant, the direction for most rapid improvement is the combination of the two. For example, if the effects of variables X_1 and X_2 are calculated as 1.00 and 2.00, respectively, and both are considered to be significant, the desired *direction* is along a line through the center of the old design and drawn so that one unit of change along X_1 will be accompanied by two units of change along X_2.

No information is supplied as to the proper distance along this line. This decision is the responsibility of the process supervisor, as are all decisions concerning this unit. A potentially huge change may be suggested. But is it practical without disturbing production? As a safety factor it is well to run an intermediate program in which small jumps are made in the indicated direction, repeating runs often enough to sharpen the precision. Alternately, the design of the completed phase may be moved in the desired direction and attached to a corner or side of the previous location.

Regardless of the change contemplated, remember that it is a serious step. With the linear design, statistics do not tell how far. The decision as to type of change and magnitude represents an intelligent decision after weighing the gamble taken and the profits which will accrue.

Decisions at the End of Each Cycle

There are several alternate actions on completion of any cycle. The process supervisor examines the results to that moment and concludes that he should:

1. Do exploratory runs along a suggested path.
2. Shift the entire pattern to a new location.
3. Continue the phase through another cycle to sharpen the contrasts enough to give him assurance of a direction of change.
4. Expand the range of one or more variables to aid in sharpening the contrasts.
5. Abandon the present variables as offering no opportunity for improvement.

All except the last are self-explanatory. Here the supervisor should not allow himself to be stampeded by an impatient management. Impatience is no part of EVOP; it is usually the consequence of early quick successes. Since large potential gains are easily detected quick successes result only when the process has been running very inefficiently. It is the small changes, which may eventually either make or break the process, which are hard to locate. Educate your management in this line of thinking and abandon a design only when you are sure that there is no profit to be obtained or when you think that there is usefulness in the indicated, but inconclusive, effects noted. Inconclusive results (i. e., nonsignificant) may well be used if they are in agreement with theory; if they contradict it, view them with suspicion, as they will probably reverse themselves with further cycles.

Restrictions

It is conceivable that there may be process restrictions preventing the move which EVOP suggests. There is nothing wrong with this; it indicates that the optimum has been reached, not for the process in its fundamental nature, but for the process represented by a particular assembly of units. Thus, the inability to move suggests process changes. It also provides an estimate of the savings which will accrue per unit of change in the desired direction. Thus, figures are available to assist in making a decision including payout time for the new equipment.

Uncontrollable Variables

It is not uncommon to encounter a variable which cannot be controlled. It may vary continuously, as with a declining catalyst efficiency, or it may vary in discrete jumps, as with raw materials from separate sources. The problems posed here are optimization before this variable assumes a new value. It is rare that this speed can be attained.

The correct answer in this situation seems to be a continuous EVOP, fully automated. A joint study of the solution to this problem is under way currently between the Statistical Techniques Research Group and the Chemical Engineering Department of Princeton University. Until the results of this study are available, some stop-gap is desirable.

For the variable with discrete jumps, and assuming that these jumps are few, parallel EVOP programs may be run, accumulating information on each one as necessitated by the outside control.

The continuous variable is more difficult. One technique currently being investigated is a simple second-order design which will provide both direction and magnitude of change of any variable. For details of second-order designs, see reference (*2*).

CONCLUSION

This brief survey of the techniques of evolutionary operation has included discussions of: its unique applicability to the needs of a chemical plant; its ability to meet the requirement of providing a program of plant runs without disturbing production; generally suitable designs; simple methods of calculating the results from the data; the interpretation of the results; a desirable form for presenting the results; and some common problems which might be encountered, with suggested solutions. There is no thought that these problems are inclusive or exclusive; others are discussed elsewhere (*1, 3*).

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Mannose in Cellulose and Pulps

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A repetition of the work of Adams and Bishop, who found a spot corresponding to mannose in commercial cotton linters by hydrolysis, subsequent oxidation of the glucose with glucose-oxidase and chromatography, corroborated their results. Similar results were obtained with purified cotton lint fibers and fuzz fibers. However, some evidence is presented that this mannose spot may be an artifact produced during hydrolysis by the action of hot acid on glucose. Efforts to increase the amount of mannose-units content in cotton by means of absorption of the solution into the cut stalk during boll growth failed. So, too, did the effort to incorporate aminoglucose similarly.

IT IS to be feared that a great many chemists still consider mannose a rare sugar although it is now known to occur very widely in the vegetable kingdom, especially as part of the wood of conifers. In fact, most cellulosic preparations contain small amounts of bound mannose. This type of mannose-containing compound is the subject of the present paper.

A complete review of the literature of this subject hardly seems necessary at this time. In addition to the book by Whistler and Smart (*1*) and to the chapter by Polglase in "Advances in Carbohydrate Chemistry" (*2*), recent papers by Merler and Wise (*3*) and by Matsuzaki and Ward (*4*), include selected bibliographies.

The present paper deals with two closely related facets of the subject; the presence of mannose, even in cotton cellulose, and the effect of this mannose content on the reactions of cellulosic pulps. Several questions are asked and, to some extent, answered. It is these partial answers that are being reported here.

ARE THERE MANNOSE UNITS IN COTTON CELLULOSE?

Although ordinary methods show no mannose units in cotton cellulose (*5*, *6*), Adams and Bishop (*7*) found that if the glucose in the hydrolyzate (which masks the minor sugars) is preferentially destroyed, mannose is found in the remainder. Adams and Bishop used a sample of commercial cotton linters. This material is known to contain two types of fibers, residual "stumps" of the long textile fibers and the short fuzz fibers (*8*). We repeated the experiments of Adams and Bishop (*6*) and corroborated their chromatography after enzymatic oxidation of the glucose. Other sugars are also indicated by spots (Tables I–IV). However, since similar spots can be formed under certain conditions from glucose, another question remains.

This question is whether the mannose is originally present or an artifact. Our experiments do not answer this question completely. We find no chromatographic spot corresponding to mannose after acid treatment of glucose, except when the basic form of IR-45 was used to deacidify. Nor did we find any after the action of oxidase on glucose, except in the one case when glucose was heated previously for 1 hr. at 120°C. with dilute sulphuric acid and then oxidized. Pretreatment with cold acid did not have this effect. This indicates the possibility that a spot similar to mannose may be formed during the acid hydrolysis of cellulose and subsequent treatments.

Our chromatograms also showed the presence of other sugars than glucose and mannose and the results in Tables I-IV should be briefly examined in this respect. Our first experiments indicated that the action of oxidase on glucose produced only arabinose (Table I), as shown by Adams and Bishop, but a repetition of this experiment (Table III, experiment 13) also gave galactose and ribose. The only differences between the preliminary test and experiment 13 was the substitution in the latter case, of the carbonate form of IR-45 for the the use of a different sample of oxidase. This last factor may be the significant one, for ribose may conceivably arise from nucleoprotein components of the enzyme and galactose from a possible 4-epimerase impurity (*9*), for the existence of which, however, we have no direct evidence.

Oxidation of a mixture of glucose, xylose, and mannose showed that mannose and xylose were partially lost during the process. Only 6% of mannose and 4.4% of xylose were recovered. This may be caused either by

Table I. Concentration of Nonglucoses in Solutions of Glucose Treated with Glucose Oxidase (as Percentages of Glucose)

Sample	*Galactose, %*	*Mannose, %*	*Arabinose, %*	*Xylose, %*
Glucose	0	0	0.014	0
Glucose, contg. 1% mannose and 1% xylose	0	0.06	0.0064	0.044
Hydrolyzate from linters pulp (viscose grade)	0.004	0.024	0.024	0.012
Hydrolyzate from Upland cotton I	0.054	0.08	0.038	0.013
Hydrolyzate from Upland cotton II	0.115	0.175	0.020	0.044

1R-120 and base form of 1R-45 used in deionizing.

Table II. Presence of Mannose Spot From Glucose After Treatment With Sulphuric Acid

Experiment	*Acid treatment*[a]	*Deacidification*	*Mannose*
1	A	IR-45 (base)	+[b]
2	B	1R-45 (base)	+
3	C	1R-45 (base)	+
4	A + C	1R-45 (base)	+
5	None	1R-45 (base)	+
6	B	1R-45 (carb.)	−
7	B	$BaCO_3$	−
8	C	1R-45 (carb.)	−
9	C	$BaCO_3$	−
10	A + C	1R-45 (carb.)	−
11	A + C	$BaCO_3$	−
12	A + C	Duolite A6	−[c]

[a] A is concentrated acid at room temperature; B dilute acid at room temperature; C hot dilute acid. For details, see text.
[b] There are also spots slower than glucose, probably reversion products.
[c] Pink color under glucose spot.

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enzymolysis or by retention of sugars by the deionizing resins.

In experiment 15, Table III, in which glucose is treated with hot dilute acid before oxidation, fructose as well as mannose was found. While this indicates epimerization, it has never been previously observed under these conditions.

Xylose and rhamnose are the only two sugars found in cotton hydrolyzates and not formed from glucose. Xylose has also been chemically identified as a component of cotton alpha-cellulose (*5*). We do not wish to draw conclusions based solely on chromatographic spots regarding the other sugars. These experiments should be checked and the mannose should be chemically identified before a definite proof of mannose in cotton is claimed, but we have corroborated the results of Adams and Bishop, using both textile cotton and fuzz fibers.

CAN MANNOSE UNITS BE ARTIFICIALLY INTRODUCED INTO COTTON CELLULOSE?

Our efforts to incorporate mannose units during the growth of the plant were unsuccessful. The experimental approach was to apply mannose in aqueous solution to the cut stem of the growing boll in the manner used by Greathouse (*10*) and later by Wolfrom (*11*) to introduce glucose-1-C^{14} into the cellulose molecule. Although the solution was absorbed by the plant, there was no qualitative increase in the mannose content of the hydrolyzed cellulose. In some cases mannose spots were not evident at all. The usual results are indicated in the last three items in Table IV.

A similar experiment was carried out introducing glucosamine hydrochloride or *N*-acetyl glucosamine. In no case (Table V) was there any increase in nitrogen content in the fiber. The usual mannose spots were formed from these fibers. An attempt to introduce glucosamine as free base did not produce a healthy boll.

EXPERIMENTAL

Mannose in the Natural Cotton Fiber

Cotton Samples. A commercial linters pulp, viscose grade, was obtained by the courtesy of the Buckeye Cellulose Corp.

A sample of upland cotton was obtained from the Southern Utilization Research Branch of the U. S. Department of Agriculture. It had been cleaned by treatment with the Shirley analyzer.

Freshly opened cotton bolls were obtained with the assistance of the Bureau of Plant Industry, U. S. Department of Agriculture, from J. G. Jenkins, Tifton, Ga. The long fibers were removed by hand. This was accomplished with very little breakage, perhaps 10%. The fuzz fiber was removed from the delinted seeds by a method which was believed to minimize the introduction of any hull fragments. This was a variant of the A.O.C.S. method for determination of residual lint (*12*). Twenty-five grams of delinted seed were placed in an unglazed earthenware container, the sides and bottom of which were splattered with 0.7 ml. conc. HCl and heated 2 hr. in an oven at 120°C. Seeds containing charred fibers or blackened tips were removed and the remainder brushed with a hand brush through a 40-mesh sieve. One and seven tenths grams (almost 7%) of fuzz fiber was obtained.

Table III. Sugars Detected in Glucose Solution Treated with Sulphuric Acid and Glucose Oxidase

Experiment	Acid treatment	Deacidification	Sugars: Gal.	Man.	Fruc.	Arab.	Ribose
13	None	None	+	−	−	+	+
14	B[a]	1R-45 (carb.)	+	−	−	+	+
15	C[b]	1R-45 (carb.)	+	+	+	+	+

[a] Cold dilute acid = details in text.
[b] Hot dilute acid = details in text.

Table IV. Sugars Detected in Cotton Hydrolyzates Treated with Glucose Oxidase

Cotton used	Sugars: Gal.	Man.	Fruc.	Arab.	Xyl.	Ribose	Rhamnose
Upland raw	+++	+	++	+++	+++	+	++
Upland[a]	+++	+	+	++	+	−	trace
Upland[b]	+++	+	+	+++	+++	−	trace
Lint (hand-picked bolls)[a]	−	+	−	++	++	−	−
Fuzz (hand-picked bolls)[a]	−	+	−	+	+	−	−
Stoneville[a,b]	++	+	−	+++	+	−	−
Stoneville[a,b,c]	++	+	−	+++	+	−	−
Stoneville[a,b,d]	++	+	−	+++	+	−	−

[a] Extracted with benzene-alcohol.
[b] Extracted with boiling 1% NaOH.
[c] Growing boll treated with mannose.
[d] Growing boll treated with *N*-acetylglucosamine.

Methods. Cotton samples were hydrolyzed after extraction with alcohol and benzene, by the method of Saeman, *et al.* (*13*), and the hydrolyzates neutralized with Amberlite IR-4B or IR-45 in the carbonate form, except where otherwise noted. In some cases, these solutions were chromatographed directly. In others, the hydrolyzates were oxidized with glucose oxidase as described by Adams and Bishop (*7*). In a few cases, quantitative determinations were made by Pridham's method of estimation (*14*) of the chromatographed sugars.

In the experiments with glucose, three types of acid pretreatment were used, scaling down the experiments in some cases.

A. One gram glucose was treated with 10 ml. 72% H_2SO_4 at 30°C. for 1 hr.
B. One gram glucose was treated with 290 ml. 2.6% H_2SO_4 at room temperature for 1 hr.
C. One gram glucose was treated with 290 ml. 2.6% H_2SO_4 at 120°C. for 1 hr.

After these treatments, or combinations thereof, the solutions were deacidified with Amberlite resins IR-120 or IR-45 (in base form or carbonate form), with barium carbonate or with Duolite A-6. When the sugars were oxidized, the oxidase treatment of Adams and Bishop was used (*7*), with 200 mg. of glucose-oxidase (Takamine Laboratory) per gram glucose.

Paper chromatography was accomplished with Whatman no. 1 filter paper, developing either with butanol-pyridine-water (10:3:3) or ethyl acetate-acetic acid-water (9:2:2). Para-anisidine hydrochloride was used as the spray (*15*).

Results. Table I represents quantitative estimates of the nonglucose sugars in sugar solutions after treatment with glucose oxidase. The discrepancies between the cotton experiments led us to suspect that mannose might be produced in small amounts from glucose.

Table II shows the effect of acid treatment on glucose. It demonstrates epimerization when the base form of IR-45 is used.

Table III shows a study of the sugars formed from chromatographically pure glucose by glucose oxidase. These results and those of Table IV, a corresponding study of cotton hydrolyzates, have already been discussed.

Attempts to Modify Cotton Cellulose During Growth

Materials. The cotton was grown in the greenhouse from Stoneville seeds obtained through the courtesy of the Bureau of Plant Industry.

Methods. The techniques of Greathouse (*10*) were used to feed aqueous solutions of various sugars to the growing boll. After the boll matured, the fibers were separated from the seed by hand and treated as in the previous section for the detection of mannose. Nitrogen was determined by the A.O.A.C. Method 34-22 (*16*).

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Effect of Waxing on Opacity and Brightness

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When a sheet of paper or paperboard is waxed its opacity and brightness decrease. The extent of this decrease is dependent not only on the composition of the sheet but also on the degree of penetration of the wax. If the sheet is quickly dipped in a molten wax bath and immediately withdrawn and immersed in ice water (simulating "wet waxing") the decrease in opacity and brightness will be much less than if the sheet is thoroughly impregnated (simulating "dry waxing"). This is illustrated by comparing the opacity and brightness of lightweight paper before waxing, after commercial "wet waxing," and after total impregnation. It is further shown by optical tests on bleached kraft paperboard handsheets waxed by various simple laboratory techniques to obtain different degrees of impregnation. Laboratory techniques involving total impregnation give lower opacity and brightness than will result from commercial waxing where impregnation may be much less, as for example in "wet waxing." Therefore, unless properly interpreted, laboratory waxing techniques may give misleading indications of what will take place commercially. Regardless of the waxing technique, decreases in opacity and brightness are less for sheets pigmented with titanium dioxide. On waxing the appearance of unpigmented paper changes to a much greater degree than the appearance of pigmented paper. Pigmentation minimizes differences in opacity and brightness resulting from variations in waxing techniques. This should result in greater appearance uniformity even within a single waxing operation where slight variations may cause differences in impregnation.

Sales appeal is based on eye appeal. In modern markets, merchandise is displayed on brilliantly lighted shelves and in well-illuminated bins and freezers and is no longer placed in shadowy corners. Effective display is closely tied in with attractive unit packaging. Without attractive unit packaging there would be little display value. Without modern display methods there would be less need for attractive unit packages. Such packages must be made of materials which will serve as a suitable background for display printing as well as fulfill the essential functional requirements.

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Many of the unit packages for food and beverages require waxed paper or paperboard for functional reasons. Waxed paper, for example, is used for breadwrappers, candy wraps, overwraps on cereal boxes, and various wrappers and liners. Waxed paperboard is widely used for packaging frozen foods, meats, and shortenings of all kinds, and for containers for milk, fruit juices, and many other beverages. Inasmuch as such unit packages will be displayed it is highly essential that they have an appealing appearance. This can only be achieved if the materials comprising them are attractive in the waxed condition.

While it is generally considered that the brightness and whiteness of a sheet after waxing are predominant factors in appearance the opacity after waxing is equally important. High opacity gives better masking of the color of the article being packaged or of any substrate, and in the case of liquid containers reduces the "shadow" of the liquid. High opacity thus enhances inherent brightness and gives a much better background for display printing.

The opacity and brightness of a sheet prior to waxing only serve to offer mere indications of its appearance after waxing. Two sheets which have similar appearance in the unwaxed state may have very dissimilar appearance after waxing.

The fact that opacity and brightness decrease when a sheet of paper or paperboard is waxed and the underlying causes for this effect are well known. Assuming constant component proportions, these properties depend on the difference in the refractive indices of the components. In an unfilled, unwaxed sheet of paper there are only two components: cellulose, with a refractive index of about 1.53 and air with a refractive index of 1, and because there is a definite difference in refractive indices substantial opacity results. When this sheet is waxed, part or all of the air is replaced with a

material having a refractive index similar to that of cellulose. Therefore, the difference in refractive indices is almost nil and the sheet becomes translucent. The effect of a low refractive index pigment (such as clay) on the opacity after waxing will be negligible, because such a filler will not result in any appreciable difference in the refractive indices of the sheet components. If a high refractive index pigment is used, however, there will then be a definite difference in refractive indices which will result in higher opacity. These points which have long been known, are summarized in Chapter XI of TAPPI Monograph No. 19 "Paper Loading Materials" (1958).

While it is possible and frequently useful to estimate the waxed opacity and brightness of a sheet containing a given amount of a high refractive index pigment, if these properties for a similar unfilled sheet are known, such an estimation will only be valid if the waxing techniques employed are identical. This is a reasonably simple matter in the laboratory but commercially the methods of waxing and therefore the degree of wax impregnation vary widely.

Essentially there are two main types of waxed paper, "dry waxed," and "wet waxed." Blends of paraffins or of waxes and a resin such as polyethylene may be used, dependent on the specific operation involved and the final characteristics desired.

In "dry waxing" (such as is frequently used for delicatessan wraps and some types of liners) the paper web is passed through molten wax and pressed through hot squeeze rolls to insure thorough impregnation, with the removal of any excess wax by doctoring. The wax therefore fills the voids in the sheet, replacing most of the air.

In "wet waxing" (for breadwraps and many overwraps and food boards) the web is immersed in molten paraffin or a blend of paraffin and resin and after going through squeeze rolls is immediately passed over chilled rolls or into a cold water bath or some other chilling device to set the wax and give a high gloss. Much of the

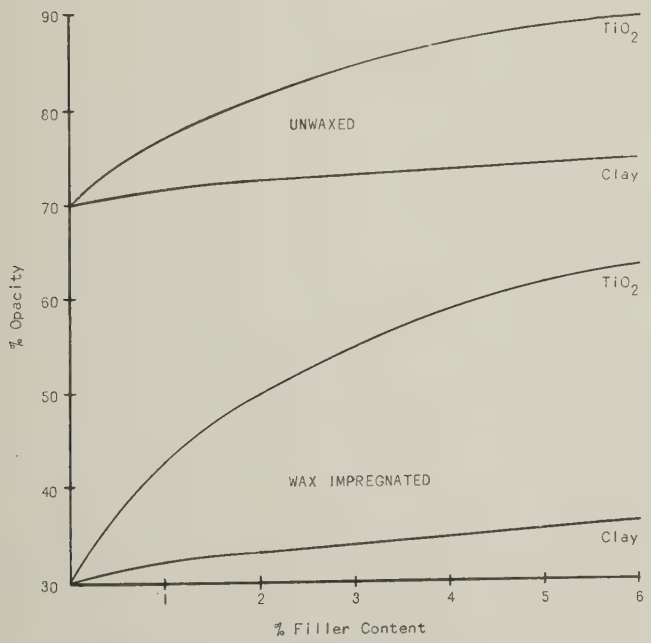

Fig. 1. Effect of total wax impregnation on opacity of 30-lb. handsheets

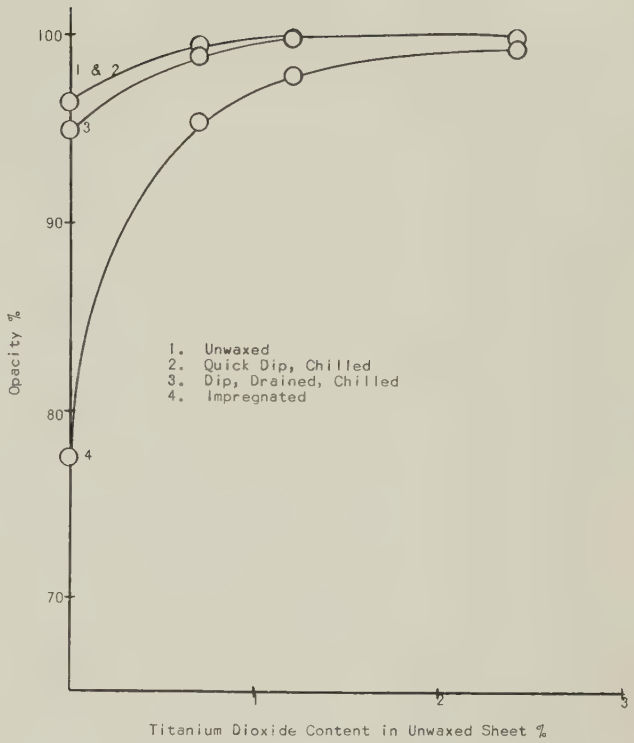

Fig. 2. Effect of waxing on opacity of 16-pt. bleached kraft handsheets

wax remains on the surface as a continuous film. In the case of paperboard containers for liquids the finished article may be dipped into molten wax for a specified length of time to insure the killing or sequestering of microorganisms, following which it is quickly drained and chilled. In any case the degree of penetration of the wax and the thickness and gloss of the surface film depend on a number of factors including the technique and time sequences in impregnation and chilling, type of raw stock, surface treatment of the sheet for "wax holdout," and composition of the molten wax bath.

In "dry waxing" where the wax (with a refractive index similar to that of cellulose) thoroughly impregnates the sheet and replaces the air (with a refractive index lower than that of cellulose) the loss in opacity and brightness is greater than in "wet waxing" where only a portion of the air is replaced with wax, and where a continuous film remains on the surface. Even when a sheet is "wet waxed," however, there may be considerable penetration, greater in some instances than in others. Such variation in penetration will be more apt to occur if the raw stocks, waxing machines, and procedures differ, but may still occur even during a single run because of operating variables. Any variation in degree of impregnation may affect opacity and brightness.

EXPERIMENTAL

The usual laboratory equipment is not adaptable to simulating the many variations in commercial waxing, even when the techniques involved in any specific case are known, which is rarely the case. Such variations exist in commercial practice where the same sheet may develop decidedly different opacity and brightness when printed and waxed by different converters.

Since total impregnation gives the most easily reproducible results, it has generally been used for obtaining much of the published data on waxed opacity and

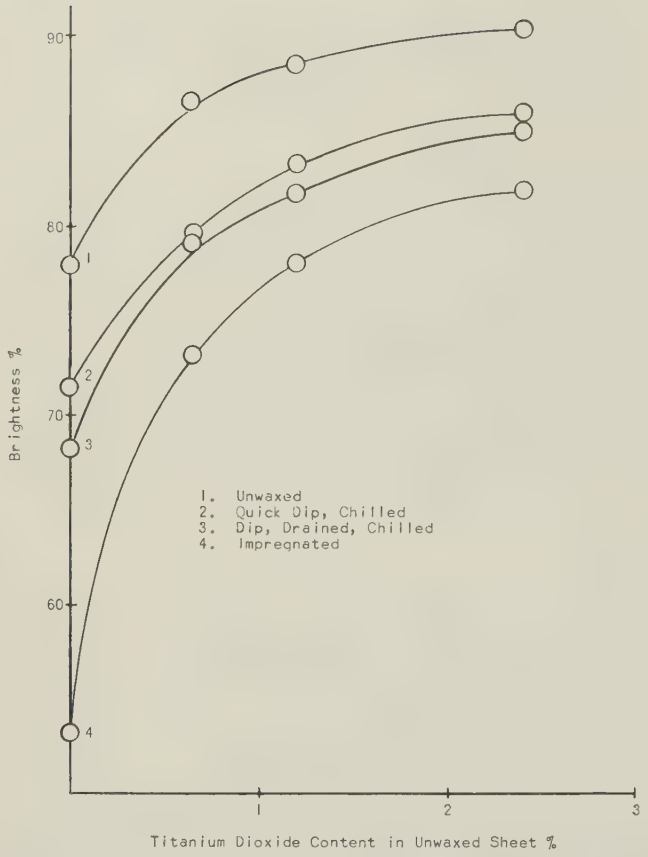

Fig. 3. Effect of waxing on brightness of 16-pt. bleached kraft handsheets

brightness. A typical example of such total impregnation is shown in the curves of Fig. 1. These represent averages for handsheets (30 lb., 25 × 40—500) without any filler and with various amounts of clay or titanium dioxide. The difference between the opacity before and after wax impregnation was much greater for unfilled or clay filled sheets (about 40 points) than for sheets loaded with titanium dioxide (about 25 to 30 points). The shape of the curves before and after waxing is characteristic. Such data are, however, only approximate, and the opacity after waxing would in the majority of cases be considerably higher if the paper were "wet waxed" commercially, than if completely impregnated.

This is shown by the data of Table I for lightweight coated wrappings, pigmented with titanium dioxide. In all cases the opacity of the commercial, wet waxed samples was higher than for those thoroughly impregnated in the laboratory. In one case where sufficient sample was available, the brightness of the thoroughly impregnated sample was much lower than that of the commercial wet waxed sample.

Similar results were obtained for laboratory handsheets, one set containing up to about 2.5% titanium dioxide and the other up to 15% titanium dioxide. The first set comprised 16-pt. bleached kraft board weighing about 67 lb. per thousand square feet, the second was 10-pt. board of about 60 lb. per thousand square feet weight.

Table I. Effect of Waxing Coated Lightweight Food Wraps

	Bread wrap		*Household wrap*	
	1	*2*	*3*	*4*
Opacity, %				
Unwaxed	78	75	68	63.5
Commercial wet waxed	63	54.5	44	38.5
Laboratory total impregnation	58.5	46.5	42	30.0
Brightness, %				
Unwaxed	...	...	..	78.5
Commercial wet waxed	...	...	..	67.0
Laboratory total impregnation	...	...	..	61.5

In all cases specimens were dipped in molten paraffin wax (138/140) at 170°F. and immediately withdrawn and immersed in ice water to simulate an extreme condition of "wet waxing." Other specimens of the same sample were immersed in molten wax, quickly withdrawn, and allowed to drain at 170°F. for 1 min., and then plunged into ice water. There was no appreciable variation in the opacity and brightness for samples drained over a time range of 1 to 3 min. before plunging into ice water. Other specimens were impregnated thoroughly by dipping in the molten wax at 170°F. for 15 min. and draining at the same temperature for half an hour. Increasing either impregnation or drainage time beyond these conditions had negligible effect on the resultant opacity and brightness.

Opacity in all cases was determined using the Bausch and Lomb opacimeter. Brightness was measured using the blue filter on the Hunter multipurpose reflectometer with a pad sufficiently thick so that additional layers had no effect on the reading. This reflectivity measurement using the blue filter on the Hunter instrument approximates "TAPPI brightness." In the second set of board handsheets reflectivity using green and amber filters was also determined to give an indication of whiteness.

The opacity of the 16-pt. samples with titanium dioxide contents ranging up to about 2.5% is shown in Fig. 2. It will be noted that the unwaxed sample and the "wet waxed" sample which had been dipped, immedi-

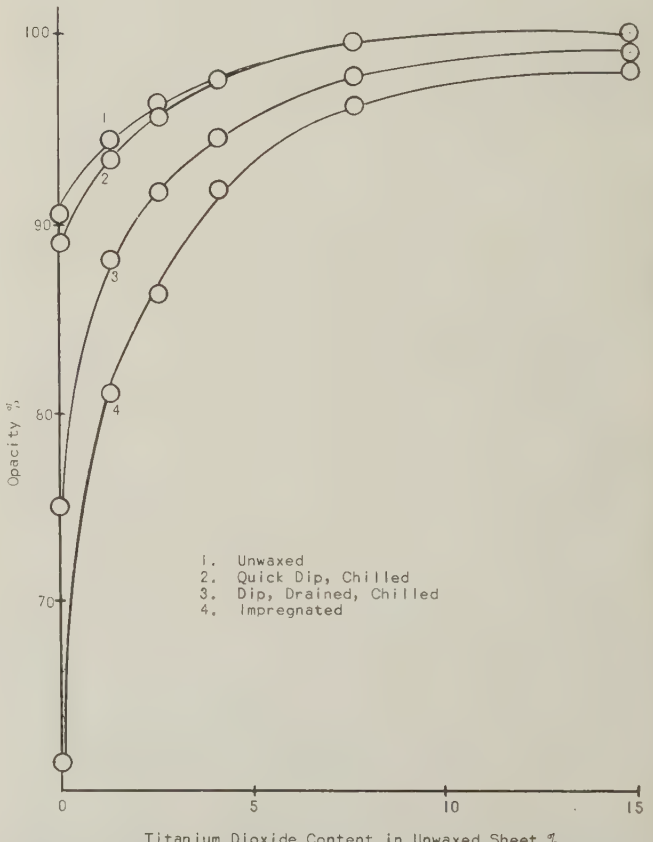

Fig. 4. Effect of waxing on opacity of 10-pt. bleached kraft handsheets

ately withdrawn and chilled had essentially the same opacity, while the sample which had been drained 1 min. at 170°F. before chilling had only slightly lower opacity. The thoroughly impregnated sample, on the other hand, had much lower opacity. It is interesting, however, to note that the differences in opacity resulting from the different waxing techniques were much less as pigmentation increased. Waxing techniques had greater effect on brightness than on opacity, as shown in Fig. 3. Here again differences resulting from the various waxing techniques were less as pigmentation increased.

The opacity for the 10-pt. boards as shown in Fig. 4 was naturally at a lower range than for the 16-pt. boards, but again the "wet waxed" samples had essentially the same opacity as the unwaxed. The opacity of those drained a minute at 170°F. before chilling was considerably lower, with the thoroughly impregnated samples having by far the lowest opacity. As in the case of the 16-pt. boards the opacity differences between the different waxing techniques were much less at higher pigmentations.

Brightness, as shown in Fig. 5, was also greatly affected by waxing techniques, just as was true for the heavier boards. As pigmentation increased, variation in waxing techniques again had less effect on brightness.

Pigmentation improved whiteness as well as brightness regardless of the waxing techniques. Similarly, as pigmentation increased, variation in waxing techniques had less effect on color. This is shown by the comparative yellowness curves of Fig. 6. (Comparative yellowness, which is an indication of whiteness, is calculated by subtracting the reflectivity, using a blue filter from that using an amber filter, and dividing the result by the green filter reading.)

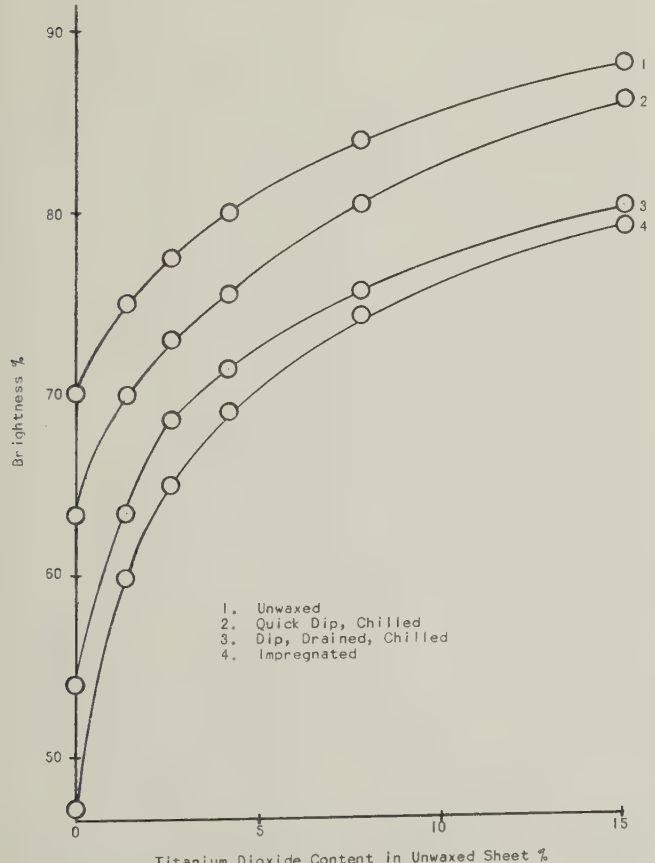

Fig. 5. Effect of waxing on brightness of 10-pt. bleached kraft handsheets

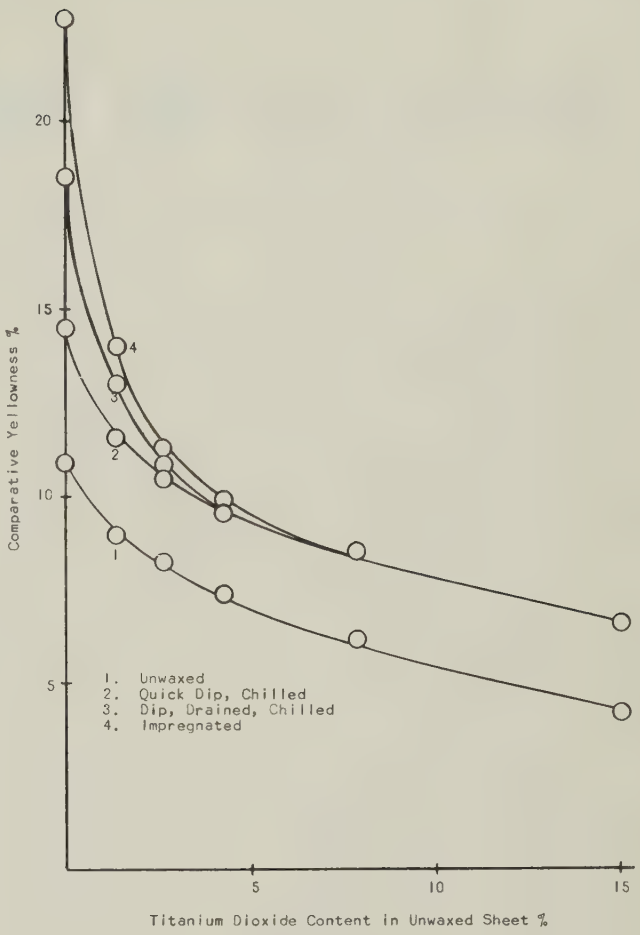

Figure 6. Effect of waxing on color of 10-pt. bleached kraft handsheets

CONCLUSIONS

When a sheet of paper is waxed, the loss in opacity and brightness is dependent on the waxing technique. If the wax thoroughly impregnates the sheet the loss will be far greater than if penetration is less.

In attempting to evaluate the appearance a sheet will have after commercial waxing it is important to consider not only its opacity and brightness before waxing but also the waxing technique that will be employed. For example, if a sheet is to be "wet waxed" any tests involving total impregnation will give lower opacity and brightness than will result commercially.

While the variation in any given commercial waxing operation may cause only slight differences in impregnation, even these may affect the resultant opacity, brightness, and color.

Regardless of the specific waxing technique, loss in opacity and brightness is less for sheets pigmented with titanium dioxide. Such pigmentation tends to minimize differences in appearance which may arise from slight variations in penetration which may occur even in a specific waxing operation, resulting in greater over-all uniformity. Uniformity is especially desirable because unit packages of the same merchandise may be displayed adjacent to each other, and should be similar as well as attractive.

Presented at the Ninth Testing Conference of the Technical Association of the Pulp and Paper Industry, Savannah, Ga., Sept. 30–Oct. 3, 1958.

Paper Test Data from Pendulum and Inertialess Testers

RUSSELL J. CAPOTT, SANFORD B. NEWMAN, and JOHN MANDEL

Breaking strength and elongation were determined for five different papers using a pendulum and an inertialess type testing machine. The tests were made at lower clamp speeds ranging from 0.02 to 20 in. per min. for the inertialess machine and from 4 to 12 in. per min. for the pendulum tester. It was found that the breaking load values obtained on the inertialess tester at clamp motions of 0.5 to 2.0 in. per min. are almost identical with those obtained on the pendulum machine at lower-clamp speeds of 4 to 12 in. per min. For the same rates of clamp separation there is close agreement in breaking strength values from the two machines. Elongations from the pendulum machine were slightly higher than those from the inertialess machine. It was concluded that the two instruments are equally sensitive when used in these ranges for the measurement of tensile strength or elongation of paper.

THE American Society for Testing Materials (*1*) specifies certain features of the apparatus used for determining tensile breaking strength of paper. Jaw edges of the specimen clamps must be adjustable for distances from 100 to 180 mm. and the center lines of the clamps must be in the same plane parallel to the direction of motion. The clamps must be so aligned that they will hold the test specimen in the same plane throughout the test without slippage. The apparatus must be able to apply a gradually increasing load to the test specimen until it breaks, the additional load applied each second being within 5% of the additional load applied in the previous second. Finally, a means of indicating the applied load at specimen-failure to an accuracy of $\pm 1\%$ is required. These requirements are met by the pendulum type apparatus which is almost exclusively used for this purpose. This is essentially the same testing machine described by the Technical Association of the Pulp and Paper Industry for determining the breaking strength of paper (*2*). The Federal Specification (*3*) is somewhat more restrictive as the description of the required apparatus in the test method could only fit a pendulum-type testing machine.

The means for measuring the elongation is apparently of less concern to specification writers. According to one procedure, elongation shall be measured at the instant of rupture of the specimen, either by means of a recording device attached to the machine, or by measuring between reference marks on the specimen. Another (*4*) merely stipulates that the means of indicating the elongation of the test specimen up to the instant of complete fracture have an accuracy of within 0.5 mm. (0.02 in.).

A survey by The Institute of Paper Chemistry (*5*) classified tensile testers according to the method of loading the specimen. Pendulum, inclined-plane, hydraulic and spring-type instruments are included and apparently all are suitable for testing paper and used for this purpose to some extent. The survey did not include a machine which (1) incorporated a weighing head moving less than 0.005 in. to measure the load applied to break the specimen and (2) separated the clamps holding the ends of the specimen at a constant rate. A commercial model of such a machine has been described in the engineering literature (*6*). It is the type of machine required in Method A of the American Society for Testing Materials specification for tensile properties of plastic films (*7*) where it is characterized as "static weighing-constant rate of grip separation" tester. For convenience, this latter testing machine shall be designated "inertialess" throughout this report. Some observations by Orchard (*8*) have shown that this designation cannot be accepted literally but for normal testing operations the effects may be considered negligible. Although Meredith (*9*) attempted no assessment of this type of machine he concluded that the ideal instrument for studying the rheology of paper would be one in which all three variables, time, load, and extension, could be varied to a quasi-infinite degree.

Broughton (*10*) and Broughton and Matlin (*11*) have described the type of inertialess tester used in this investigation in some detail and found it useful for studying the behavior of paper yarns, of deformation forces in drying paper, and of corrugated board adhesives. They also presented load-elongation data for a number of hand and machine made papers. Their investigation was limited to clamp speeds between 0.2 and 2 in. per min. because they found that with the higher head speeds available, 5, 10, 12, and 20 in. per min., the response of the recorder was inadequate to record instantly the output of the load cells. To avoid this inadequacy specific restrictions are specified for testing textile materials with this machine (*12*). The head speed permitted is expressed in terms of gage length and elongation at break. A 2-in. gage length for paper approximates the minimum permitted by some specifications (*1*, *3*) though TAPPI (*2*) requires a minimum gage length of about 7 in. Obviously, longer gage lengths and materials with higher breaking elongation may permit the use of higher head clamp speeds.

Practical operating considerations with particular reference to textile materials are discussed in some detail by the American Society for Testing Materials for different types of testers (*12*). Carson (*13*) and others (*5*) have noted that the rate of loading of a specimen in a pendulum-type testing machine is not constant when the stressing clamp is moved at constant speed. In addition, it has been shown (*5*) that the moment of inertia of the pendulum leads to significant spurious increases in indicated breaking strengths. The effect of this "follow through" is most pronounced at small loads and high rates of head motion. Inertia effects have been discussed by Schiefer (*14*). Machines of the

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Table I. Identification of Papers

Sample no.	*Description*
1	Kraft wrapping paper
2	Mimeograph paper, 100% chemical wood (substance 20)
3	Mimeograph paper, ground wood (substance 20)
4	Mimeograph paper, 100% chemical wood (substance 20)
5	Standard newsprint, 100% groundwood

Table II. Rates of Clamp Motion

Pendulum, in per min.	*Inertialess, in. per min.*
4	0.02
8	0.05
12	0.2
	0.5
	2.0
	5.0
	10.0
	20.0

static weighing-constant rate of grip separation type are relatively free of inertia effects.

Control testing usually involves the determination of such properties as tensile strength and elongation. The inertialess testers equipped with autographic extensometers and sensitive dynamometers are designed to yield this information in a form which is suitable for studies of rheological behavior. They provide a means of collecting data for investigations of basic interest during routine operations. The recording of complete stress-strain curves permits the correlation of empirically measured shape characteristics of these curves with service behavior (*15*, *16*). Before the relatively new autographic testing machines can be adopted for control testing of paper it is desirable to determine the testing conditions that will yield data comparable to that obtained from equipment now in use. The work described in this paper was undertaken to make this comparison for some representative papers with a considerable range in strength and elongation. The study was carried out in accordance with a statistical and systematic design.

MATERIALS AND EQUIPMENT

Papers used in this study are listed in Table I. Sample 1 was obtained as a roll, 24 in. wide and 500 ft. long. Samples 2, 3, and 4 were received as reams of $8^1/_2$ by 11-in. sheets. The standard newsprint, sample 5, was in the form of pads, 12 by 18 in.

The inertialess tester used had longer screws but in all other features was identical with available commercial models.* It incorporates flat plate grips for clamping the specimen with the upper grip suspended from the load cell which rests on a rigid, stationary, horizontal member. The load cell employed bonded wire resistance strain gages for detecting and recording load and is accurate to better than ±0.5%. A cell with a 1 to 50-lb. range was used for all of these tests. The output of the strain gage is recorded on a moving chart. A synchronous motor drives the chart at speeds from 0.2 to 50 in. per min. permitting considerable magnification of the crosshead motion. The lower clamp is fastened to the moving crosshead which is driven at constant speed by two vertical drive screws. By means of a set of change gears, crosshead speed may be varied from 0.02 to 20 in. per min.

Details of the conventional pendulum paper testers are adequately described in the available literature (*5*, *17–19*). Paper specimens were tested on a commercial instrument in which the stressing clamp was moved at a constant rate by means of a hydraulic drive.† The clamp is driven at 4, 8, or 12 in. per min. In addition to the calibrated quadrant for indication of load the machine was equipped with a scale which gave the elongation in a 7-in. gage length.

EXPERIMENTAL

One yard long sheets of sample 1 were cut from the roll and numbered consecutively. Individual sheets of samples 2, 3, 4, and 5 were numbered consecutively as they lay in the package or pad. The sheets were divided into two piles, one having the even numbered sheets and the other containing the odd. Eleven specimens 0.59 in. wide and approximately 8 in. long were cut from each sheet. Odd numbered sheets were cut with the 8-in. dimension in the machine direction while even numbered sheets were cut with this dimension in the cross direction. The 11 specimens from each sheet were randomized and eight specimens were allocated to the inertialess tester and three to the pendulum. Eight head speeds were used with the inertia-

* The equipment used is essentially that described in "The Instron Tester" (*6*). It is designated model TT C1.

† Model No. 37-4-EL24 of the Thwing Albert Instrument Co.

Table III. Breaking Load as a Function of Lower-Clamp Speed[a]

Speed of lower clamp, in. per min.	*Sample* / *Specimen direction*	*Breaking load, lb.* 1 M	1 C	2 M	2 C	3 M	3 C	4 M	4 C	5 M	5 C
					Inertialess						
0.02		16.58	10.04	9.42	5.69	9.46	5.40	13.94	8.22	6.41	2.73
0.05		16.45	10.44	10.16	5.65	9.59	5.49	13.94	8.55	6.58	2.84
0.2		17.46	10.75	10.27	5.96	10.23	5.85	14.78	9.11	6.86	2.97
0.5		18.57	11.06	10.36	6.35	10.22	6.01	15.58	9.36	6.88	3.06
2.0		18.64	11.69	11.21	6.37	10.70	6.24	16.36	9.96	7.18	3.21
5.0		17.82	11.87	11.22	6.78	10.75	6.43	17.01	10.11	7.38	3.28
10.0		8.80	11.55	7.89	6.82	7.30	6.59	10.41	10.30	5.30	3.36
20.0		3.74	5.76	3.37	6.99	3.23	5.39	4.73	9.01	2.40	3.02
					Pendulum						
4		18.47	11.67	10.64	6.55	10.78	6.34	15.98	9.80	7.27	3.26
8		18.94	11.93	11.14	6.98	11.13	6.44	16.69	10.35	7.46	3.26
12		19.64	12.30	11.28	7.00	11.35	6.63	16.69	10.56	7.46	3.48

[a] All breaking load values in the table are averages of 25 measurements.

Table IV. Elongation as a Function of Lower Clamp Speed[a]

Speed of lower clamp, in. per min.	Sample Specimen direction	Elongation, % 1 M	1 C	2 M	2 C	3 M	3 C	4 M	4 C	5 M	5 C
					Inertialess						
0.02		1.38	2.25	1.27	3.60	1.32	2.11	1.62	2.93	1.02	1.60
0.05		1.38	2.26	1.31	3.26	1.31	2.03	1.61	3.02	1.04	1.60
0.2		1.36	2.17	1.32	3.56	1.34	2.17	1.64	3.20	1.05	1.61
0.5		1.39	2.10	1.30	3.45	1.31	2.11	1.71	3.13	1.00	1.59
2.0		1.32	2.10	1.32	3.18	1.26	2.06	1.63	3.18	0.98	1.52
5.0		1.38	2.06	1.23	3.52	1.17	2.08	1.61	2.97	0.96	1.53
10.0		1.44	1.92	1.30	3.20	1.24	1.92	1.68	2.84	1.01	1.41
20.0		1.44	2.04	1.31	3.18	1.30	1.98	1.71	3.04	1.06	1.30
					Pendulum						
4		1.55	2.38	1.44	3.58	1.42	2.25	1.81	3.32	1.14	1.55
8		1.58	2.28	1.48	3.89	1.48	2.16	1.87	3.31	1.14	1.47
12		1.61	2.38	1.44	3.82	1.51	2.22	1.82	3.47	1.08	1.57

[a] All elongation values in the table are averages of 25 measurements.

less machine and three with the pendulum paper tester as listed in Table II. The higher speeds on the inertialess tester were eliminated from consideration because the response of the recorder was inadequate to instantly record the output of the load cell.

The papers were tested in sets which consisted of two sheets of the same consecutive numbers from all materials. For example, the number 1 and number 2 sheets from all materials constituted set number 1. One set was tested at a time, first by the inertialess, then by the pendulum tester. The set order and the order of the materials within a set were randomized.

The specimen grips were 7 in. apart at the start of the tests. Specimens were conditioned for at least 24 hr., and tested, at 50 ± 2% relative humidity and 23 ± 2°C.

RESULTS AND DISCUSSION

The results for tensile strength and elongation for all testing speeds are given in Tables III and IV, respectively. Averages of 25 determinations are listed for each sample, at each speed, in each direction for each testing machine. The relations for tensile strength are shown graphically in Figs. 1 to 4. For elongation the effect of speed is very small, especially over the limited range of speeds studied on the pendulum instrument. Therefore, graphs for the elongation data are not included.

Figures 1 to 4 show that the effect of speed on tensile strength is considerable both for the inertialess and pendulum machines. This correlates with work reported by Green (*20*) who found that pendulum tensile strengths increased significantly with increase in

Table V. Analysis of Variance for Individual Samples

Source of variation	Degrees of freedom	Mean square Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
			Tensile Strength—Inertialess			
Direction	1	2875.	1144.	1126.	2161.	914.
Speed	4	28.77	10.84	9.25	37.46	2.92
Sheet	24	3.13	2.84	0.33	3.99	0.42
Dir. × speed	4	1.57	2.34	0.39	2.17	0.17
Dir. × sheet	24	2.86	1.48	0.44	3.19	0.61
Speed × sheet	96	1.00	0.48	0.16	0.54	0.090
Remainder	96	0.91	0.49	0.15	0.60	0.085
			Tensile Strength—Pendulum			
Direction	1	1863.	654.	799.	1448.	619.
Speed	2	10.3	4.32	2.36	7.97	0.54
She	24	2.05	2.10	0.51	1.77	0.35
Dir. × speed	2	0.95	0.11	0.30	0.15	0.19
Dir. × sheet	24	2.68	1.43	0.37	2.62	0.46
Speed × sheet	48	0.73	0.33	0.28	0.57	0.11
Remainder	48	0.76	0.34	0.20	0.55	0.095
			Elongation—Inertialess			
Direction	1	41.2	276.9	38.7	131.2	20.2
Speed	4	0.11	0.39	0.72	0.22	0.051
Sheet	24	0.15	0.46	0.13	0.27	0.054
Dir. × speed	4	0.058	0.47	0.021	0.14	0.0049
Dir. × sheet	24	0.101	0.39	0.163	0.30	0.023
Speed × sheet	96	0.064	0.25	0.035	0.19	0.021
Remainder	96	0.058	0.25	0.031	0.20	0.020
			Elongation—Pendulum			
Direction	1	22.1	200.	20.5	88.2	6.32
Speed	2	0.058	0.41	0.023	0.088	0.018
Sheet	24	0.088	0.32	0.11	0.28	0.053
Dir. × speed	2	0.055	0.27	0.077	0.14	0.080
Dir. × sheet	24	0.090	0.26	0.13	0.24	0.062
Speed × sheet	48	0.052	0.21	0.054	0.20	0.015
Remainder	48	0.044	0.19	0.043	0.22	0.023

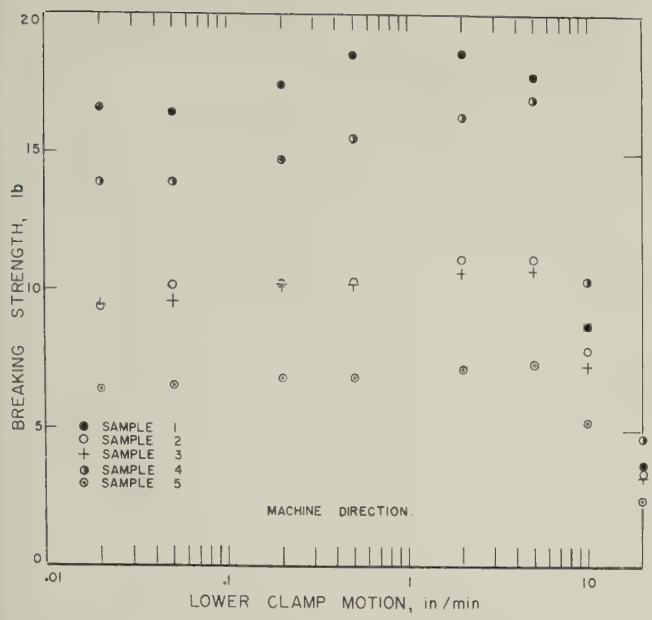

Fig. 1. Breaking strength as a function of clamp speed for five samples of paper tested in the machine direction of an inertialess tester

speed of testing for 7 out of 10 cases (five papers—two directions).

A striking feature of Figs. 1 and 2 is the sudden apparent drop in tensile strength at speeds exceeding 2 in. per min. for some of the samples tested on the inertialess tester. It has been noted in previous work (*11*) that paper samples with 2-in. gage lengths could not be used with inertialess tester clamp speeds of more than 2 in. per min. This drop is a manifestation of the inadequate response of the recorder and not an effect of speed of testing on the strength of paper.

Variance analyses were made for the tensile strength and elongation values from each tester for each sample, omitting speeds higher than 2 in per min. or the inertialess machine for which recorder lag was apparent. The results are shown in Table V. A significant, though small, sheet-to-sheet variability in all materials is revealed by the analyses of variance. However, the effect of speed on tensile properties is not affected by this variability, as can be seen from the fact that the speed × sheet interaction mean-square is in all cases very close to the remainder mean-square which may be considered a measure of error.

The error mean-square, labelled "remainder," is seen to vary appreciably from material to material, but its value is consistent for the two instruments for each given material. In order to study the precision in more detail, analyses of the data were made separately for each of the two directions and at only two speeds.

This study is shown in Tables VI and VII. The speeds chosen for this study were 0.5 and 2.0 in. per min. for the inertialess, and 4 and 8 in. per min. for

Table VI. Reproducibility of Tensile Strength Measurements

Property	*Sample* 1	2	3	4	5
Machine Direction					
Tensile strength, lb.					
Average[a]					
Inertialess	18.50	10.78	10.46	15.97	7.03
Pendulum	18.70	10.89	10.96	16.34	7.36
Standard deviation[b]					
Inertialess	1.27	0.61	0.65	0.72	0.52
Pendulum	1.17	0.74	0.62	0.86	0.35
Coefficient of variance, %[b]					
Inertialess	6.9	5.6	6.2	4.5	7.6
Pendulum	6.2	6.8	5.6	5.3	4.8
Cross-Machine Direction					
Tensile strength, lb.					
Average					
Inertialess[a]	11.38	6.36	6.12	9.66	3.14
Pendulum	11.80	6.76	6.39	10.08	3.26
Standard deviation[b]					
Inertialess	0.73	0.72	0.20	0.60	0.12
Pendulum	0.68	0.31	0.23	0.58	0.15
Coefficient of variance, %[b]					
Inertialess	6.4	11.3	3.3	6.2	3.8
Pendulum	5.8	4.6	3.6	5.8	4.6

[a] Of 25 measurements at speed 0.5 and 25 measurements at speed 2.0 in. per min. for inertialess, and of 25 measurements at speed 4 and 25 measurements at speed 8 in. per min. for pendulum.
[b] Corresponding to the variability of single measurements made on the same sheet.

Table VII. Reproducibility of Elongation Measurements

Property	*Sample* 1	2	3	4	5
Machine Direction					
Elongation, %					
Average[a]					
Inertialess	1.356	1.304	1.284	1.670	0.990
Pendulum	1.566	1.456	1.454	1.840	1.140
Standard deviation[b]					
Inertialess	0.14	0.13	0.14	0.20	0.14
Pendulum	0.16	0.18	0.15	0.16	0.10
Coefficient of variance, %[b]					
Inertialess	10.3	10.0	10.9	12.0	14.1
Pendulum	10.2	12.4	10.3	8.7	8.8
Cross-Machine Direction					
Elongation, %					
Average[a]					
Inertialess	2.104	3.314	2.082	3.158	1.556
Pendulum	2.332	3.736	2.208	3.314	1.510
Standard deviation[b]					
Inertialess	0.26	0.76	0.21	0.55	0.17
Pendulum	0.28	0.55	0.31	0.59	0.16
Coefficient of variance, %[b]					
Inertialess	12.4	22.9	10.1	17.4	10.9
Pendulum	12.0	14.7	14.0	17.8	10.6

[a] Of 25 measurements at speed 0.5 and 25 measurements at speed of 2.0 in. per min. for inertialess, and of 25 measurements at speed 4 and 25 measurements at speed 8 in. per min. for pendulum.
[b] Corresponding to the variability of single measurements made on the same sheet.

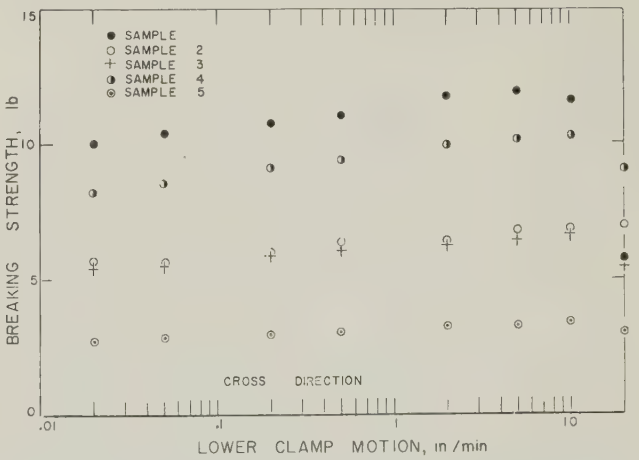

Fig. 2. Breaking strength as a function of clamp speed for five samples of paper tested in the cross-machine direction on an inertialess tester

Table VIII. Rate of Clamp Separation for Three Speeds of the Lower Clamp of a Pendulum Tester

Lower clamp speed / *Sample*	*Rate of clamp separation, in. per min.* — *4 in. per min.*	*8 in. per min.*	*12 in. per min.*
1 M[a]	0.34	0.67	1.06
1 C[a]	0.72	1.41	2.14
2 M	0.53	1.00	1.54
2 C	1.53	2.58	3.64
3 M	0.49	1.00	1.42
3 C	1.11	2.17	2.94
4 M	0.46	0.87	1.23
4 C	1.07	1.89	2.96
5 M	0.22	0.40	0.60
5 C	0.70	1.33	2.03

[a] Samples designated M were tested in the machine direction, those designated C in cross-machine direction.

the pendulum tester since at these speeds the results given by the two instruments are very close to each other. The standard deviations given in Tables VI and VII are measures of the scatter of the differences observed, for each instrument, for the measurements made at the two speeds on specimens from the same sheet. The ranking of the materials according to the magnitude of the standard deviation is almost identical for the two instruments for each property. In fact the standard deviations corresponding to each of the 5 materials are practically identical for both instruments. It is interesting to note that the large differences between the standard deviations corresponding to the five materials, especially for tensile strength, fail to be reflected by the coefficient of variation. Thus, the variability in tensile measurements for each material appears to be essentially proportional to the magnitude of these properties for that material.

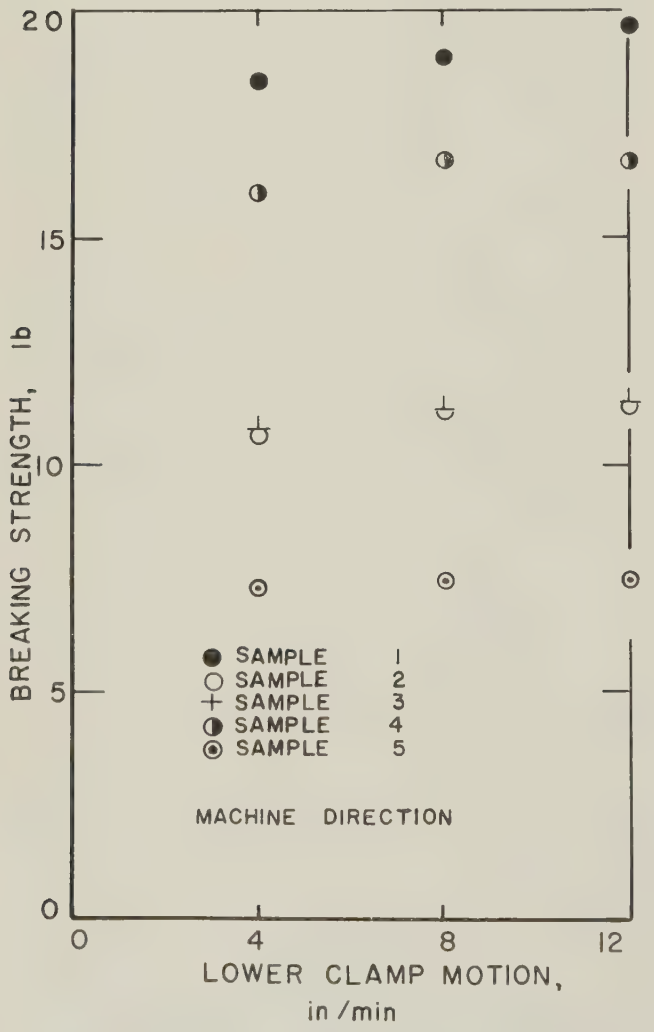

Fig. 3. Breaking strength as a function of lower-clamp speed for five samples of paper tested in the machine direction on a pendulum tester

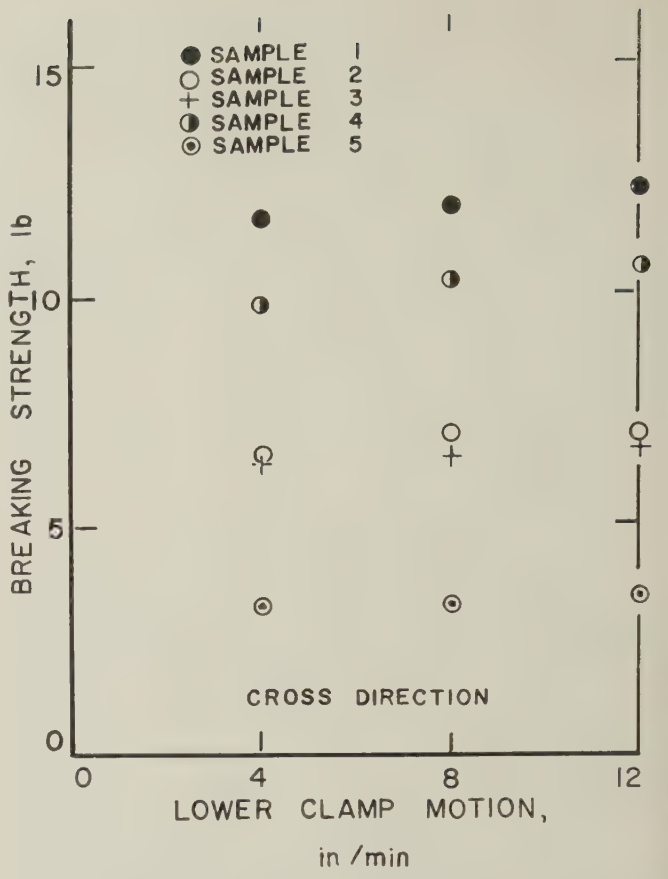

Fig. 4. Breaking strength as a function of lower-clamp speed for five samples of paper tested in the cross-machine direction on a pendulum tester

In assessing the effects of speed of clamp motion in the two machines, it must be noted that for the same rate of lower-clamp motion the effective rate of loading is greater for the inertialess than for the pendulum machine. In the latter, the upper clamp is not fixed but moves down as the angle of the pendulum with the vertical plane becomes larger. This does not occur in the inertialess tester where the upper clamp is supported by a rigid member. The actual rate of clamp separation in the pendulum tester is determined not only by the speed of the lower clamp but also by the mechanical properties of the specimen. The rate was measured for all five samples in both directions and the results are given in Table VIII. It is at once obvious that the rate of clamp separation for the pendulum tester is much smaller than implied by the lower-clamp motion. The total range for all samples at all speeds is 0.22 to 3.64 in. per min. Because of the effect of clamp speed, pendulum and inertialess tensile strengths must be compared under the same conditions of loading. Almost all of the pendulum tests were carried out at clamp separation speeds that are covered by the range of inertialess tester experimental rates of 0.2, 0.5, and 2.0 in. per min. Pendulum tensile strengths for each of these speeds were obtained by linear interpolation from the observed values. The inertialess observed values are

shown plotted against the pendulum interpolated tensile strengths in Figs. 5 and 6. In general, the agreement between values from the two machines for all samples is close in the region investigated. However, the slopes of the breaking load-clamp separation rate relationships are significantly higher for the pendulum than for the inertialess tester.

As has been previously noted in reference to Table IV, elongation is much less sensitive to speed than is breaking strength. Indeed, in the measurements made with the pendulum tester, speed has no significant effect. This is also corroborated fairly well by Green (*20*) whose pendulum elongations showed significant increases in only two out of 10 cases. Elongations determined with the pendulum are slightly but significantly higher than those obtained with the inertialess tester. The difference is due, at least in great part, to difference in extensometer design. The pendulum extensometer appears to record elongation after the maximum load has been reached. The force required to tear the paper specimen is sufficient to prevent the immediate release of the actuating mechanism. As a result, some of the indicated elongation is merely due to gross deformation of the specimen after primary failure. The inertialess elongations were measured conventionally, from the point of load application to the point of maximum load and primary failure, which can be read with precision from the load-elongation record.

CONCLUSIONS

Tensile strength values obtained from a pendulum and an inertialess tester at similar rates of clamp separation are in good agreement over the range 0.2 to 3.5 in. per min. for a specimen 7 in. in length. A lower clamp motion of 8 in. per min. on the pendulum machine for the papers tested is approximately equivalent to 2 in. per min. with the inertialess equipment. For most specification testing purposes, values obtained under these conditions on the two machines should be acceptably comparable. Ultimate elongations measured on the inertialess are slightly lower than those obtained on the pendulum tester due to extensometer design. The extensometers could be modified so that they would uniformly indicate elongation at the start of the break instead of at some stage in the tearing of the specimen.

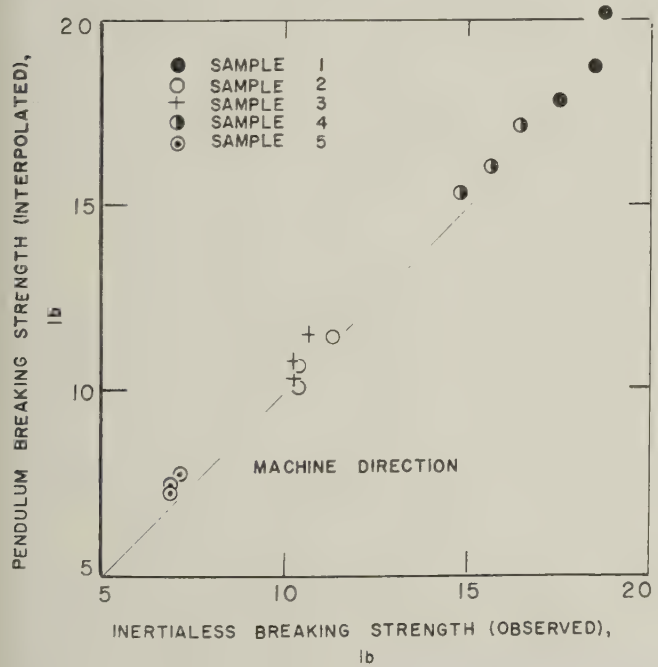

Fig. 5. Pendulum tester breaking strengths plotted against those determined with an inertialess tester for five samples of paper tested in the machine direction. The inertialess values were observed. The pendulum results were obtained by linear interpolation of the data observed at three speeds

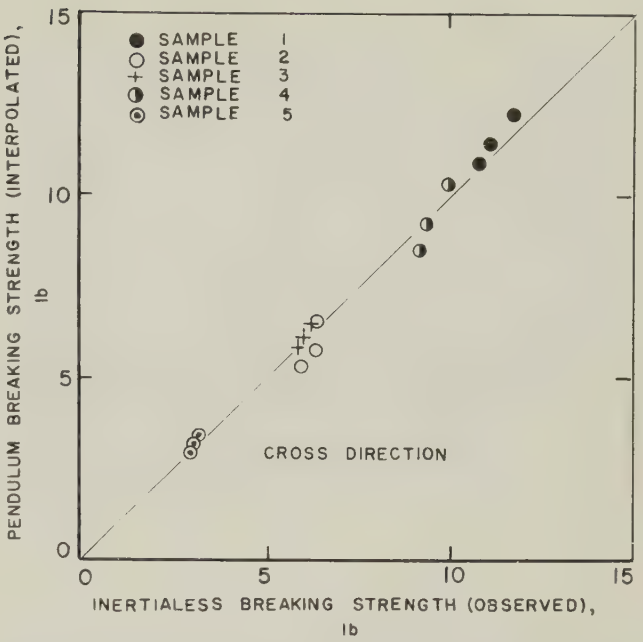

Fig. 6. Pendulum tester breaking strengths plotted against those determined with an inertialess tester for five samples of paper tested in the cross-machine direction. The inertialess values were observed. The pendulum results were obtained by linear interpolation of the data observed at three speeds

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Photographic Examination of Paper and Paperboard Surfaces to Predict Halftone Printing Quality

ROBERT O. RAGAN

The fiber topography of a paper surface to be printed with halftones has a direct bearing upon the continuity and fidelity of the halftone reproduction. As attempts to define surface smoothness in terms of instruments have not been entirely successful, a photographic technique and camera was used for the purpose of making quick visual comparisons of printing surfaces. It was found that the conventional method for making photomacrographs through a microscope equipped with bellows and plate attachment was not entirely suitable as a quality control instrument. The problems encountered in the use of such apparatus by unskilled operators dictated the desirability of improving certain features such as portability, fixed focus, self-contained illumination, viewing in a brightly lighted room, ease of sampling and sample identification, and by all means speed of operation. These improvements were considered and incorporated in a new camera apparatus which uses an 8-mm. motion picture camera lens for the optical system. The apparatus serves also for visual inspection. Paper surfaces containing no mineral filler or clay coating can be made to photograph more distinctly by first wiping, in the grain direction, with an alcohol suspension of titanium dioxide. Illumination at an angle of $12^1/_2°$ is oriented across the grain for greatest detail. Commercial printing results on various grades of material illustrate the reliability of the photo examination technique for predicting a surface suitable for halftone printing, particularly when material already proved satisfactory is used as a comparison. The photographs of printing surfaces show that it is the roughest parts in the area which determine the print quality. The photographic technique locates such areas which are quite often obscured in random or "averaging" test methods. In addition to the demonstrated use of photomacrographs as a means for quality control, the technique provides valuable aids to research concerning printing or paper surfaces, and can be used to define such surfaces.

At the present time there is probably no problem of more universal concern to the graphic arts industry and also to the paper and board manufacturers than the problem of "printability." After years of indifference, it is well that the paper manufacturers and the printers are now making a concentrated combined effort to define the problem in terms of instrument tests so that conversation between the paper mill and the printer will be on a common technical basis. The cry for "smoother" paper must be more elaborately defined.

It is not the purpose of this paper to make a critical evaluation of the many instruments and techniques which have undertaken to measure and define so-called printability, but to describe a technique which has proved quite successful as a means of expressing to the board and paper suppliers an interpretative picture of printing surfaces based upon past printing experience.

When an attempt was made to study printing problems by means of photographs, it was soon discovered that existing equipment and techniques need refinement if a practical quality control method was to result. The first part of this presentation is devoted to a discussion of the problems encountered, and how they were solved in the development of a camera designed specifically for photographing paper surfaces. The latter portion of the discussion will illustrate how photographs can be used to predict the quality of halftone printing.

DEFINITION AND SCOPE

"Printability" is an expression which should be deleted from the vocabulary of any technical discussion, because the term as such has no specific meaning. Let us define "printability" as the physical property of a surface which enables the printer to transfer ink from the printing plate to the surface and have the results look exactly like what he wants them to, with a numerical rating of 100 to signify complete success. This definition is no more absurd than the requests from the printing industry to the paper mills to supply such a material.

The more the problem of ink and paper is studied, the more apparent it becomes that there are separate and distinct physical properties involved which will not fit into a common denominator to be expressed by any one instrument. In this discussion we are not concerned with the gloss-absorbency of the paper surface, which means the rate of soaking up the ink to give a glossy or dull appearance. We are concerned, however, with the surface configuration of the paper which will effect the degree of halftone-fidelity. The reason for using the term halftone-fidelity is the fact that surface smoothness alone must be qualified by other factors such as com-

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pressibility in order to produce a print in which the dots of the halftone engraving are faithfully reproduced, preferably without the loss of a single dot. It will be shown later how important the loss of only a few dots can be to the over-all quality of the printing.

The need for the evaluation of the printing surface by means of photographs arose many years ago through experience in printing by the gravure process on solid bleached sulphate. The board supplier offered an improved grade, made with a different furnish on a different paper machine. The printing results were not as good, but of course this was attributed to the fault of the ink and the press. All physical tests showed that the two paperboards were equal. In the laboratory, the presence of the large intrafiber voids could be seen

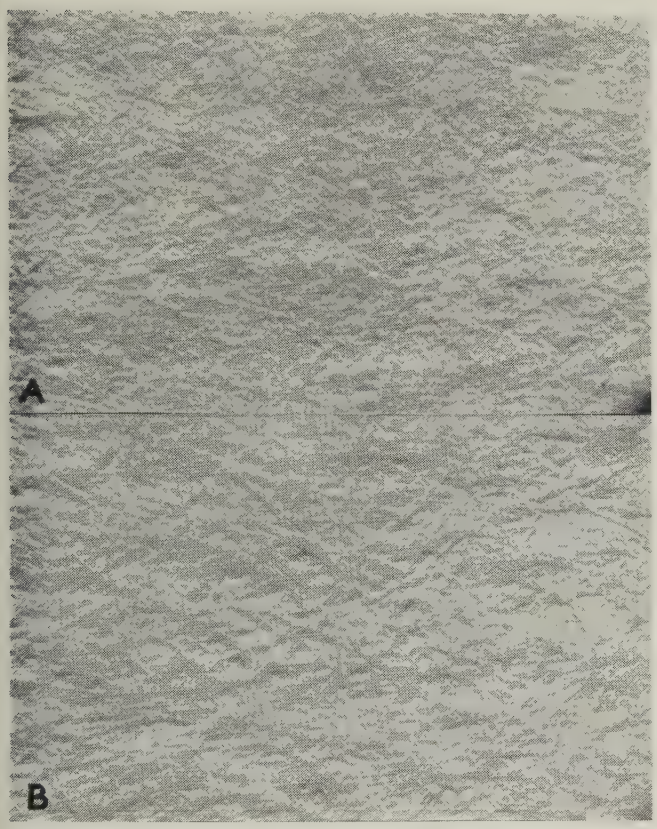

Fig. 1. Photomacrograph (23×) of solid bleached sulphate boards: (A) satisfactory, before mill change, and (B) unsatisfactory, after mill change

by inspection through a binocular microscope of 20× power under oblique lighting of the sample. A bellows attachment was installed, and a studio spot light was used for illumination in order to take photographs to present to the mill. Upon examination of the photographs shown in Fig. 1, the machine tender said, "Now, I see what you mean by surface smoothness."

DEVELOPMENT OF THE CAMERA

In establishing the photographic technique as a means for quality control inspection, many problems were experienced in using the conventional equipment for photographing through a microscope fitted with bellows. For example, it was rather cumbersome to inspect the ground glass with the extended bellows. Considerable time was required to cut the board or paper samples, fit the section onto the microscope stage and move the

Fig. 2. Prototype of camera apparatus with viewer in place

sample to find the desired area. Even with the utmost care in marking the film holder, the identity of samples was sometimes confused. Other considerations made the services of a skilled photographer a prerequisite. Enough experience was accumulated showing the potential value of photographs, however, to warrant the designing of a camera specifically for use in taking photomacrographs of paper and paperboard surfaces.

The essential features of such a camera were considered to be as follows:

1. The equipment should be portable and useable on location by unskilled help in ordinary room light.
2. The focusing should be semifixed so that the magnification was always the same in each photograph.
3. The illumination should be constant so that the exposure would vary only due to the reflectance of the material or gradual aging of the light.
4. The camera should have a means for mechanically moving either the objective or the sample so that a wide area could be examined quickly and conveniently.
5. The camera should have provision for variable F stops so that focusing inspection could be made with sufficient illumination to make the image readily visible on the ground glass, and then the diaphragm should be stopped down to provide a practical exposure time.

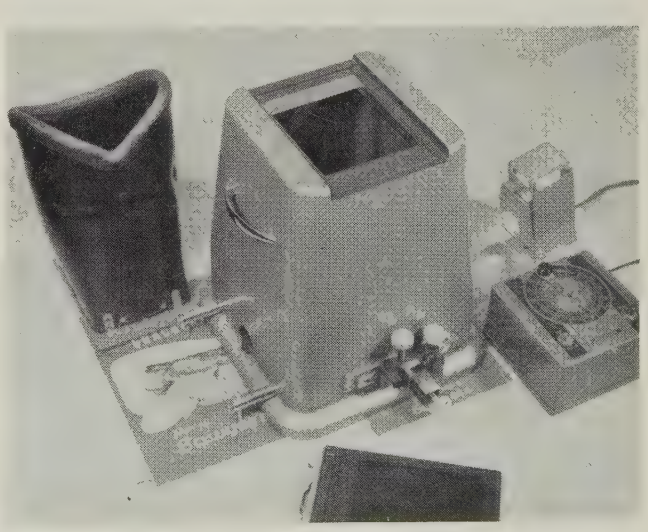

Fig. 3. Commercial model of the camera, with viewer unattached

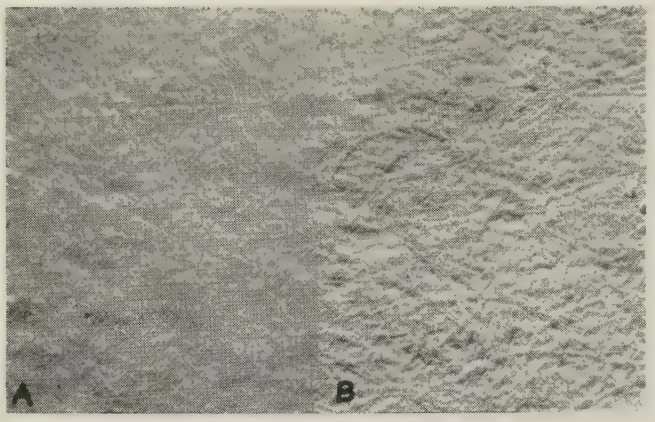

Fig. 4. Sulphate board, showing detail of fiber configuration of (A) plain surface and (B) surface printed with white ink

6. All of these controls should be readily available from the outside of the camera so that quick and easy operation would be provided.

7. There should be some way of marking on the film itself the identification of the sample so that no mistaken identity could be made in the processing.

8. Last of all, the camera should be able to photograph any section desired from a large sheet without the necessity of cutting out sections.

The first problem was the selection of a suitable objective for direct projection of the image onto the plate, and one which would give a flat field with a comparatively short distance of the plate to the lens. The various microscope objectives available were investigated and rejected. It was found that the commercial lens used for an 8-mm. motion picture camera, turned backwards, gave the most satisfactory results. The lens finally adopted was that with an aperture of F 1.9 and a focal length of 13 mm. Such a lens also provided the necessary diaphragm adjustments. The lens assembly was mounted in a crudely construsted aluminum box with a proper light lock and for moving the lens laterally over the surface, the lens was attached to a microscope stage slide mechanism. It was still necessary however, to adjust the diaphragm by manipulation of the diaphragm ring through the finger holes in the bottom half of the camera. Figure 2 shows a prototype of the camera apparatus.

The problem of identifying each film was accomplished by providing a glass slide underneath the film holder as close to the film as possible. The legend was written on this glass slide with china marking opaque ink which could be removed after each photograph. In this manner the photographs were permanently identified on the negative.

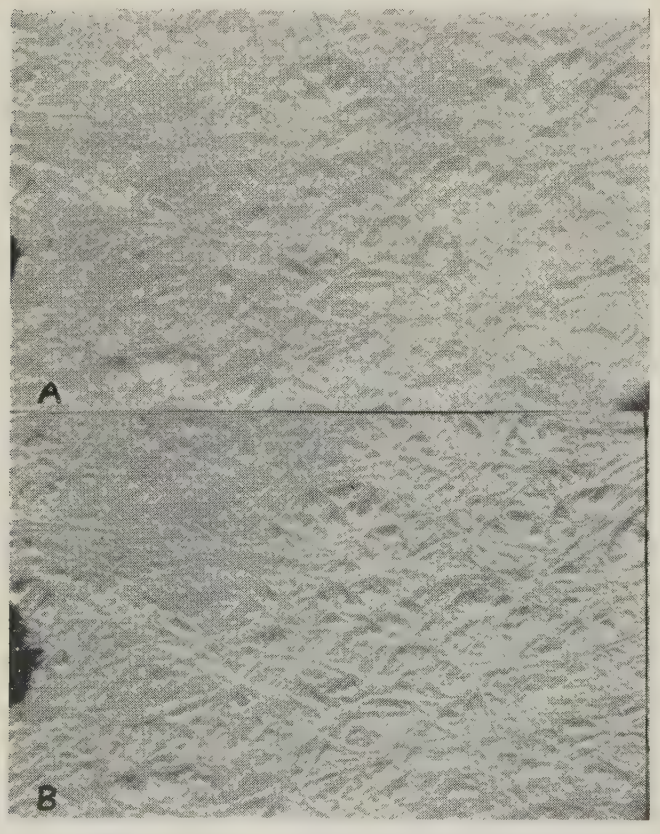

Fig. 5. Detail of fiber configuration of (A) plain surface and (B) surface wiped with special white ink

DESCRIPTION AND USE OF THE CAMERA

Further improvements were made when the prototype was redesigned and a commercial model was custom made by an engineering concern. (Erdco Engineering Corp., Addison, Ill. Not commercially available. Further details can be supplied by the author.) Note in Fig. 3 that the body of the camera is made from a heavier aluminum casting to reduce the vibration and to make the focus more stable. The light and inspection mirror can be attached on any one of the three sides depending upon the particular convenience to the operator. The diaphragm control has been brought to the front by means of a slide indicator. The lateral adjustment is accomplished by the microscope slide mechanism and a travel of 1-in. total in either direction is provided. (The importance of the travel will be apparent later.) In order to accommodate and change instantly from Polaroid to cut film, a ring adapter is provided which will fit either the standard 4 by 5 cut film holder or the Polaroid Graphlex back.

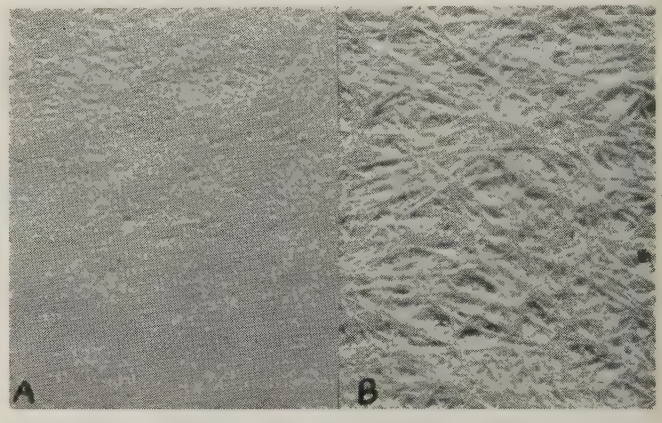

Fig. 6. Solid bleached boards: (A) cylinder, in satisfactory use, and (B) fourdrinier, not satisfactory for substitution

The distance of the lens to the film holder was kept as short as possible and still cover the 4 by 5 film area without constriction through the lens barrel. The resultant magnification of this assembly is 23 diam. Changes in the dimensions could be made to provide a more convenient magnification, for example, 25 diam.

The camera base, not shown here, is a rigid flat plate

with a counter sunk 1-in. hole to expose the sample. In use, the whole apparatus is set on the sample laid on solid flat table top.

It was found that the illumination of this sample should be across the grain, and for the sake of convenience a 100-watt projection-type lamp in a reflector housing with condenser lens was set at a distance of 10 in. The angle of illumination most satisfactory for producing the greatest detail in a wide variety of fiber surfaces was found to be 12.5°. Note in Fig. 3 the light source is attached in fixed position to the camera base.

A word about the film and photographic development. The use of high-speed panchromatic film, Royal Pan, exposed at F 16 for 3 sec. and developed for 7 min. in full strength D11 developer was found to give the best detail. In making the paper prints from the negatives, high contrast technique was again used.

When using the Polaroid film the best results were obtained with type 44 film exposed at 6 sec. so that $2^1/_2$ min. developments could be used. The clarity and the contrast of the Polaroid print is not as good as that obtained by using the Panchromatic film. The results using the Polaroid film, however, are sufficiently adequate for routine control, especially when the time factor is considered. If multiple copy detailed technical

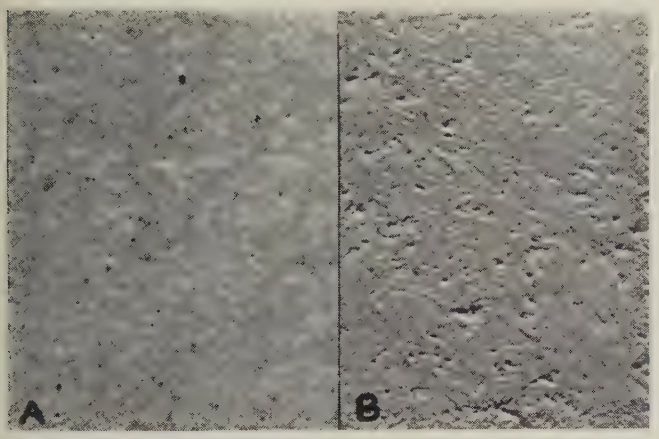

Fig. 7. Clay coated papers for roto printing: (A) satisfactory, (B) not satisfactory

reports are to be produced, the use of the Panchromatic film is then to be recommended.

The camera design described has all the desired elements, particularly speed. A Polaroid photograph can be obtained in 3 min. The camera can also be used for inspection of the paper or board surface without even taking a photograph. The one drawback, however, is the cost of manufacture.

Even though the mechanical aspects of the camera technique were solved, another problem encountered was that of producing clear and more distinct definition of the fibers in the surface of bleached boards or papers. It has been noticed that the paper fibers of clay coated boards photographed in great detail, while the photographs of the solid bleached material were lacking in sharpness of contrast. It was also observed that the detail of the fiber configuration was made more clear if photographs were taken of the portion of the printing made with a gravure white first-down color printed on the solid bleached sulphate board. This effect is illustrated in Fig. 4.

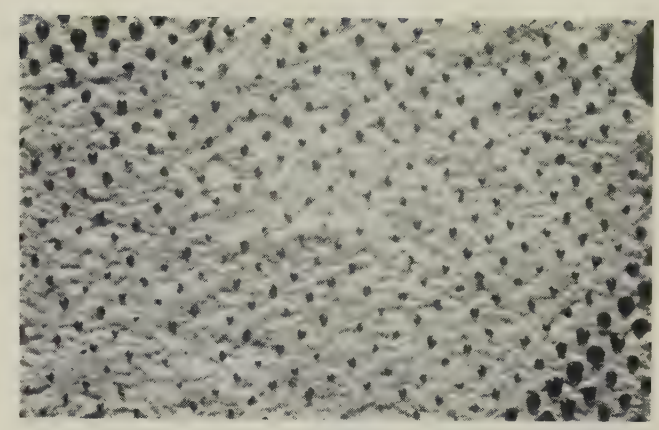

Fig. 8. Halftone printed on clay coated paper showing a comparison between halftone dots and intrafiber voids

In order to simulate this effect in the laboratory, a technique was developed for making a draw down using alcohol-dispersed white aniline ink. The normal alco-

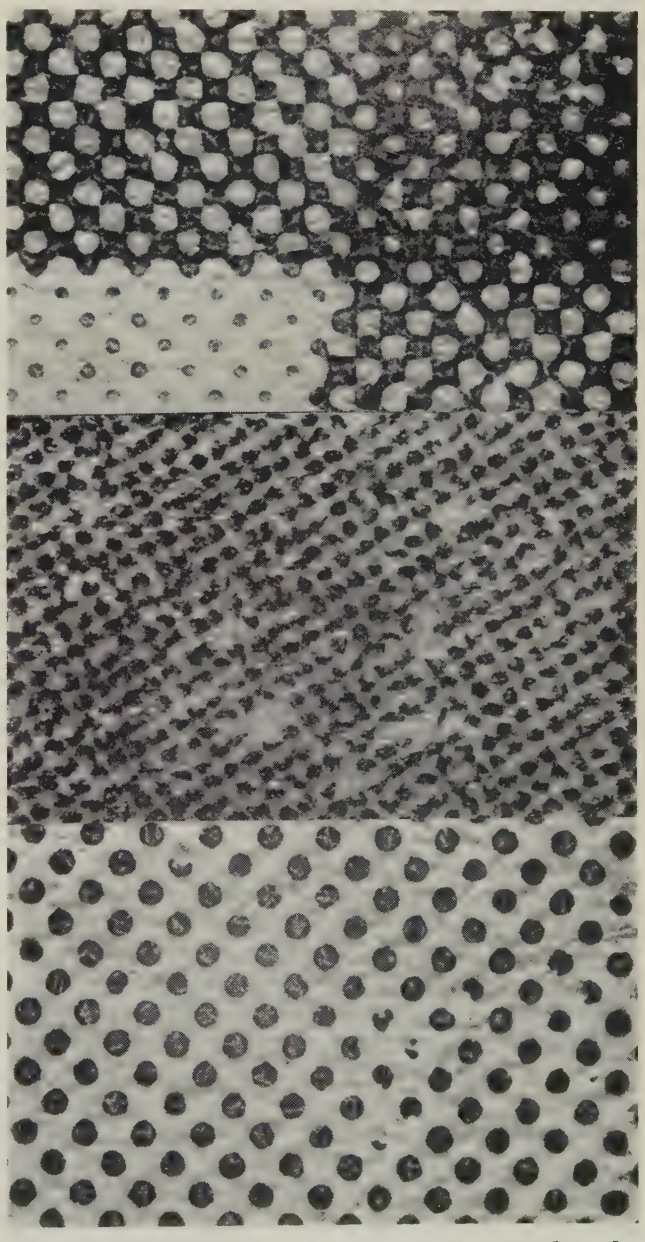

Fig. 9. Photomacrographs of printed sheets; the relatively few dots missing caused profound effects on the appearance of the prints

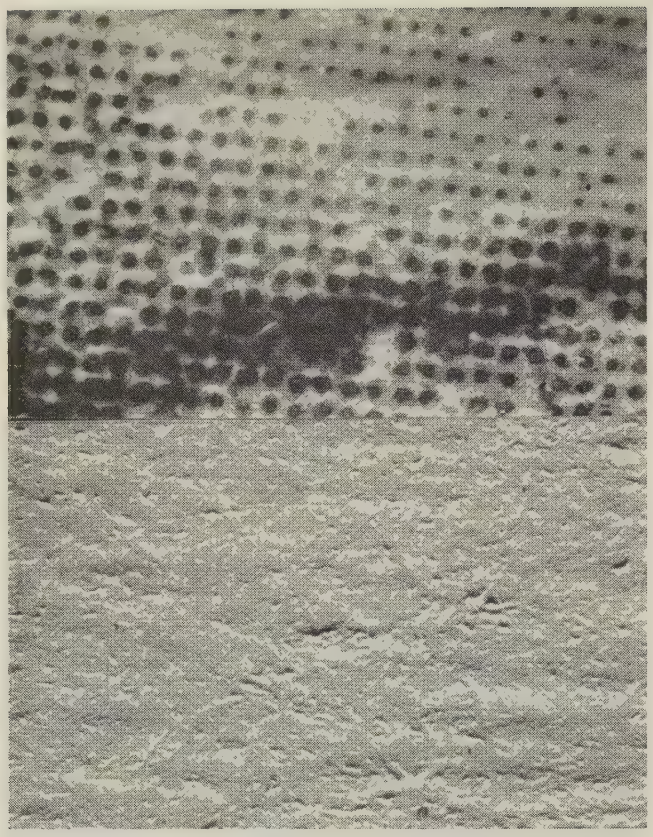

Fig. 10. Printed and unprinted surface, showing comparison between unprinted dots and rough spots on the plain board

hol type white aniline ink is diluted with 3 parts of alcohol; a 6-pt. steel doctor blade is used for a wiper to make a tight, flat draw down of the aniline ink, with the grain on the paper to be photographed. Careful study of the fiber configuration before and after this wiping technique (see Fig. 5) indicated that there is no disturbance of the fiber configuration due to the draw down. This study was made not only by means of photographs but also by visual inspection using a binocular microscope.

Although the white coating does tend to fill up and level out the very fine irregularities, these have been found to be too fine to affect seriously the fidelity of the halftone printing. It is the large intrafiber voids which are the problem.

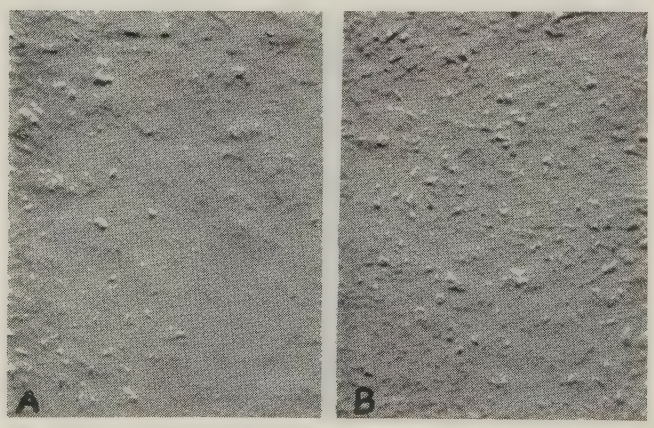

Fig. 11. Coated solid bleached board samples from the same run: (A) roll no. 2; (B) roll no. 16

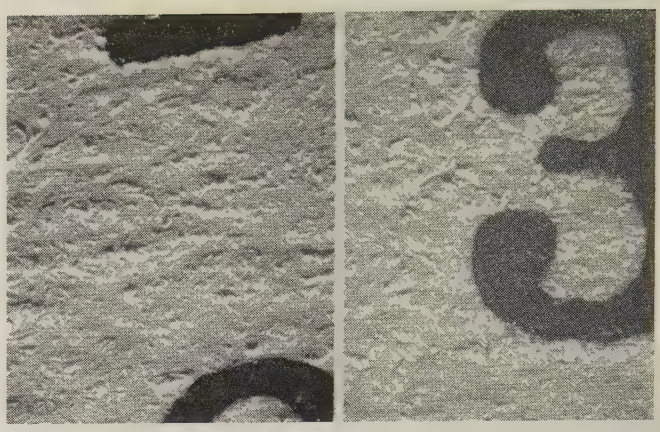

Fig. 12. Areas on same board only 1 in. apart

Now let us see what advantage such a procedure offers to the printer and paper producer alike.

APPLICATION OF THE METHOD

First and foremost, the photographs provide an immediate comparison of over-all surface smoothness in relation to expected print quality for halftones. Even though the photographs cannot be given a numerical rating, the comparison to a known standard is sufficient. No printer or paper mill is without some past experience regarding the printing results of the material in question, whether it be an improvement desired, or a substitution. So using the known paper as a basis, comparisons can be made. Figures 6 and 7 are examples.

Figure 8 shows a comparison of the size of the halftone dot to the size of the intrafiber voids.

This brings up the question of how representative or how fair is it to take only a very small $^{3}/_{16}$-in. section of a big sheet of paper and base conclusions on only this small area? Especially in the printing of Benday tints, or pastel halftones, and in all process work, it is the roughest part of the board which determines the print quality. Figure 9 shows missing dots on several printed samples. The printing plate cannot be instructed to miss certain areas because they are not representative of the major portion of the surface. Average smoothness does not count. The dots which do not print are more important to over-all results than those which do. In the preliminary scanning of the sample, the roughest portion is deliberately selected for photographing.

Figure 10 illustrates the difficulty when determining smoothness by instrumentation means, such as air flow.

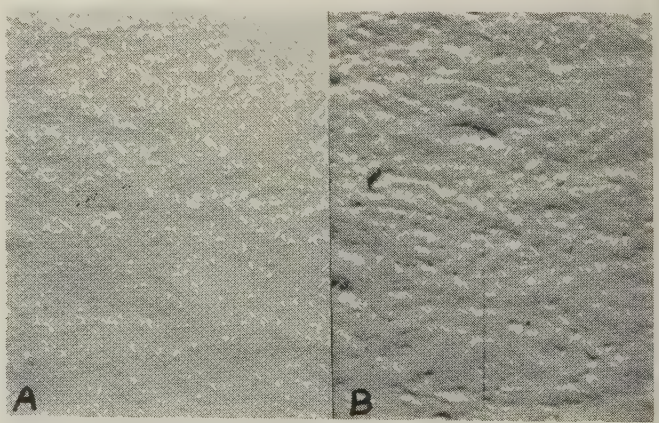

Fig. 13. Latex clay coating: (A) trailing blade; (B) air knife

It would be interesting to calculate the probability of an air flow ring being placed at exactly the proper location to measure this particular defective area.

The photographs also serve as a means to measure and record the uniformity of repeat runs, variations within a given run (Figs. 11 and 12), effect of fiber size or structure of wire and wet end conditions, configuration of clay coated surfaces (Fig. 13), etc.

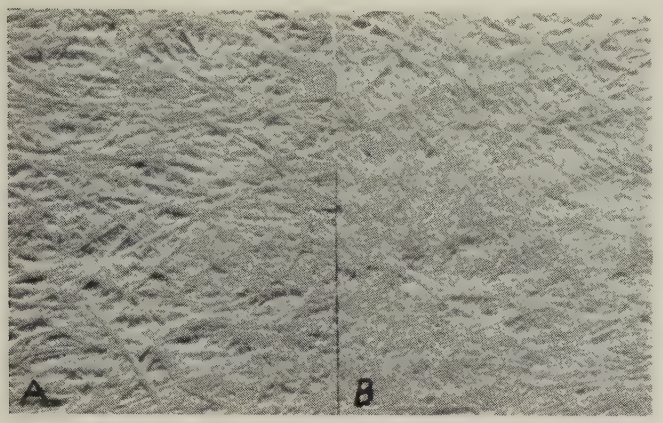

Fig. 14. Fourdrinier board on which the felt side (A) is rougher than the wire side (B); the felt side had been marked as the smooth side

The question of whether the felt, or the wire side of a fourdrinier paper or board is the smoothest for halftone printing can also be determined by photographs. The practical answer to this depends upon particular machine conditions, but in general, the wire side contains more fines, and most often gives the best halftone fidelity (see Fig. 14). It should be mentioned here that sometimes a gross roughness which is readily apparent to the unaided eye will iron out under printing impression, and is not as important as intrafiber voids which can be seen only with greater magnification. The examination of incoming paper materials to determine whether the mills' designation of the "smooth side" coincides with the printers' experience is consequently an important time saving application for the camera and has a relationship to the quality of the printed job.

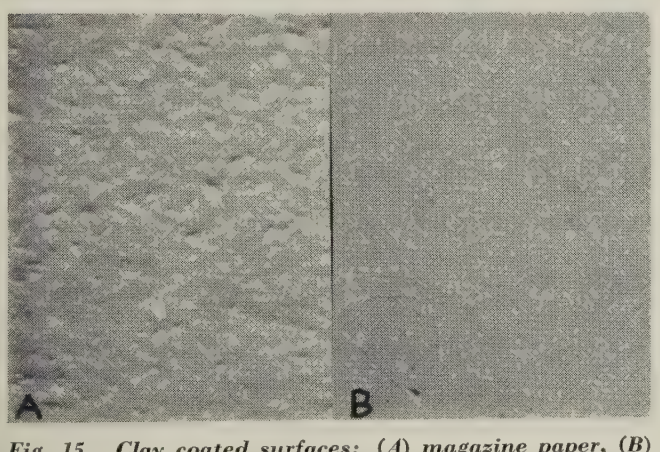

Fig. 15. Clay coated surfaces: (A) magazine paper, (B) paperboard

It is no longer possible to surmise anything from the name or the grade of the paper or paperboard regarding the excellency of the printing surface. Clay coated, gloss litho papers at one time were considered tops for print quality—with boxboard at the bottom of the list and considered a very poor surface for producing high quality process reproductions. Many boxboards on the market today, both plain and clay coated have smoother halftone printing surfaces than a majority of the clay coated papers as is shown in Fig. 15.

The use of photomacrographs permits evaluation of the surface of competitive samples which are too small in size, or too fully printed (see Fig. 16) to be reliably tested by other methods. This affords a means for determining what is occurring in the industry.

CONCLUSIONS

The use of photomacrographs as a means for quality control, and as an aid to research and development, is worthy of serious consideration. This technique can be a very valuable tool until a satisfactory instrument for assigning numerical ratings is developed. A photograph can serve as a means for the printer to define the desired printing surface to the paper mill, which in turn can use the photograph for a guide in the selection of furnish and machine conditions. It should be emphasized that the method presented here is most reliable when concerned with the problems of halftones and Benday tints, and the most particularly when the gravure or letterpress printing process is used.

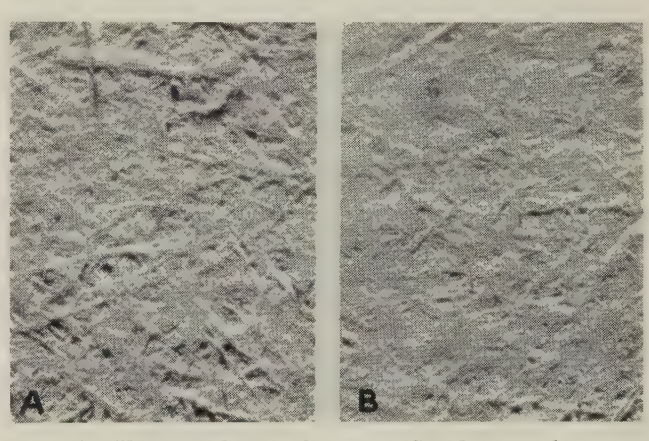

Fig. 16. Unprinted areas from two Sunday supplements, with (A) mealy printing and (B) smooth printing

A surface satisfactory for halftones is invariably smooth enough for good solid printing, however, if the gloss-absorbency factor is also suitable.

The idea of taking photographs of paper surfaces is certainly old, but with a more convenient camera apparatus and on-the-spot development of the print there is a definite place for extensive use of such photographs in the graphic arts and in the paper manufacturing industries. It is true that paper surfaces can be visually inspected through a microscope, but such comparisons are not as reliable or as definite as side-by-side viewing of photographs. As has been said many times, one picture is worth a thousand words. Let's use more photographs.

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Suitability of *Phragmites Communis* for Viscose Rayon Manufacture

YEHIA A. FAHMY and MOHAMMED A. ABOU STATE

Chemically suitable viscose pulps were obtained from Egyptian *Phragmites communis* by a prehydrolysis-sulphate pulping process in both the laboratory and the pilot plant. The filter clogging constant K_w of the viscose solutions prepared from these pulps were largely dependent on the viscose viscosity whether most of the oxidative degradation occurred during purification of the pulp bleaching or during aging of the alkali cellulose. The viscose solutions of the *Phragmites communis* pulps had similar K_w values as those of viscose solutions prepared from commercial beechwood viscose-grade pulps of the same disperse viscosity. Spinning trials were made with two different samples of viscose prepared from the experimental pulps. The resultant yarns compared favorably in mechanical and chemical properties to commercial wood-pulp rayon.

MAINLY the bisulphite and, to a lesser extent, the prehydrolysis-sulphate pulping processes are used industrially for the production of viscose pulp. The raw materials used are mainly softwoods and hardwoods. Reeds and straws, with the exception of Arundo donax, are not used commercially for this purpose. This is because these materials contain more noncellulosic material that is difficult to remove as compared to wood, and they are less abundant than woods in the principal pulp-producing countries.

Phragmites communis is one of the most important reeds and the most common in Egypt. It grows widely at lakes shores in the Delta as well as on the Nile and channel banks. There is but little information in the literature on the suitability of *Phragmites communis* for viscose pulp production. Jayme produced bleached pulps with 0.13% ash from the deleaved plant by prehydrolysis-sulphate process, using sulphurous acid for prehydrolysis. Duration of sulphate pulping was 6 hr. (*1*). However, no data on the production of viscose from *Phragmites* pulps and its suitability for spinning have been published.

Pulps to be suitable for the manufacture of viscose rayon must be of high chemical purity (*2*). They should contain at least 90% alpha-cellulose. The hemicellulose content of the pulp must be low, the amount in commercial pulps usually being about 3%, and is removed to a great extent in the first step of viscose manufacture, i.e., pulp alkalization. The ash should not be more than 0.15% and the silica not more than 0.05%, otherwise they remain more or less in an undissolved fine form in the obtained viscose and lead to difficult filterability by clogging the filter cloth. Moreover, different metallic ions may interfere with the reactions occurring in aging and sulphidation, during the viscose preparation process. Other noncellulosic materials as lignin and extractives must be present in the pulp only in a very small amount. Industrial viscose pulps possess normally an average degree of polymerization (D.P.) of 800. However, pulps of D.P. as high as 1200 are used for the production of high-tenacity rayon for special purposes, such as tire cords. The majority of the different cellulose fractions in the pulp must possess a D.P. around the average value. R. Vuori (*3*) concluded that the presence of long-chain fractions diverging greatly from the average chain length is responsible for filter clogging. The degree of whiteness of viscose pulps must be at least 80% as assurance of essential freedom from the noncellulosic materials.

However, a pulp satisfying these specifications may not be suitable for the viscose process. This is because the analytical chemical data of the pulps are the average value of the different kinds of cells (fiber and parenchyma) of which the pulp is composed and which have slightly different chemical compositions. The more complex is the anatomical structure of the raw material, the more is the nonuniformity of the pulp. In nonuniform pulps, some cells may be more than sufficiently pulped and thus have more alpha-cellulose than the average value, while some others contain much less alpha-cellulose than the value required for a viscose pulp. The fact that softwood pulps are composed almost entirely of tracheids while hardwood and reed pulps are of more complex nature may be the reason for the fact that the viscose obtained from hardwood pulps generally causes more filter clogging than that obtained from softwood.

The reactivity of a pulp toward the different steps of viscose preparation affects the filtrability of the viscose. This reactivity depends on the original biostructure of the different layers of the cell wall and its degree of retainance during the different pulping and bleaching steps (*4*). The reactivity also depends upon the frequency of the more reactive amorphous regions of the cellulose chains in relation to the crystalline regions. Due to poor reactivity, some cells may not dissolve completely and hence deliver a viscose which contains fiber debris or gel particles. These may clog the filter material. The higher the percentage of the gel particles in the viscose, the worse is its filtrability. Incomplete dissolution also influences more or less the colloidal nature of the viscose and this is of prime importance technically. Yet, the colloidal character of the viscose and hence its filtrability can be varied to a degree by varying the conditions of the different steps in the viscose process. The aging of the alkali cellulose, the amount of carbon disulphide used in xanthation, and the press factor of alkali cellulose are most important factors affecting the filtrability (*5*).

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The filtrability of viscose solutions is often expressed in terms of the filter clogging constant K_w, according to Hermans and Bredeé (*6*). In this investigation the German method of the "Fachgruppe der chemiche Herstellung von Fasern" was used (*7*). In this method the grams of viscose filtered under a constant pressure of 2 atm. are determined after 20 min. (P_1) and after 60 min. ($P_1 + P_2$), whereby P_2 is the amount of viscose filtered after 40 min. The K_w is then calculated as follows:

$$K_w = 10^5 \times \frac{\left(2 - \frac{P_2}{P_1}\right)}{P_2 + P_1}$$

The factor 10^5 is used merely for convenience of magnitude of number. The K_w is theoretically unaffected by the viscosity and other factors affecting the rate of filtration. It is dependent on the filter material used and the active filter surface. This value has been criticized by some authors because the inner structure of the viscose i.e., the number, the size, and the nature of the molecular aggregates are not taken into consideration (*8*). Also, the swelling, deformation, and inhomogeneity of the filter material causes a deviation from the theoretical straight line of Hermans and Bredeé law (*9*). Correction for these factors was suggested by Trieber, but do not hold in all cases (*9*). To eliminate any probable effect of viscosity on K_w value, the comparison of different viscose solutions should be either done at the same viscosity or the K_w should be corrected for viscosity according to Vosters (*10*). This method is sufficiently accurate especially in studying normal viscoses from different raw materials or in varying the preparation conditions of viscose where the divergencies are of considerable order (*8*).

OBJECTIVE OF THE STUDY

The objective of this study was to determine the suitability of Egyptian full-grown *Phragmites communis* for the production of viscose rayon yarn. The raw material was analyzed, and then laboratory pulping and purification experiments were made to estimate the optimum working conditions. Both the bisulphite and the prehydrolysis-sulphate pulping processes were used in this series. The best laboratory experiments, which were made in an autoclave having a capacity of about 1 kg. of raw material, were repeated in a pilot plant having a capacity of 25 kg. of raw material to determine any probable difference in the results. Viscose samples were then prepared from the pulps in a pilot plant by varying the conditions of the different steps of viscose manufacturing within an economic range. The best conditions leading to a viscose, of suitable industrial composition and possessing a suitable K_w value were to be chosen. Especially the effect of the degree of degradation of cellulose during the aging of alkali cellulose on the filtrability of the subsequent prepared viscose was to be studied. A comparison between the degradation of the cellulose during pulp bleaching and that during the alkali cellulose aging regarding the effect on the viscose filtrability was also studied. This was done by starting from the the same unbleached pulp. In one experiment this pulp was bleached mildly to deliver a bleached pulp with high D.P. so that the aging of the alkali cellulose was to be done under severe conditions. In the other experiment the bleaching was done under severe conditions so as to reduce the D.P. to a much lower value, hence the aging was carried out under mild conditions to attain the same degree of degradation of the alkali cellulose. The viscose samples of these two experiments had to have approximately the same viscosity and their filter clogging constant values were to be estimated. Finally, viscose samples for spinning purpose were to be prepared and the spun rayon fibers were chemically and mechanically tested.

EXPERIMENTS AND RESULTS

The chemical analysis was done principally according to the German Standards.

Analysis of the Raw Material

The chemical analysis of the used *Phragmites communis* was as follows: furfural, 14.28% (corresponding to 19.6% pentosan); lignin, 15.58%; extractives (methanol-benzene), 4.7%; ash, 10.36%; silica in ash, 24.75%.

It is evident that *Phragmites* contains much more ash and silica than woods. Yet after deleaving, the ash content of the stems was 6.9%. The leaves constitute 18% of the raw material and contain 17% ash.

Pulping Experiments

After applying different pulping methods on deleaved *Phragmites* with the acidic bisulphite and the prehydrolysis-sulphate processes at different pulping conditions, a suitable unbleached prehydrolysis-sulphate pulp with the following composition was prepared from deleaved material: yield, 36.6%; alpha-cellulose, 95.84%; furfural, 1.96% (corresponding to 2.69% pentosan); lignin, 0.41%; ash, 0.074%; D.P., 1365 (calculated from viscose viscosity); chlorine consumption, 1.1%. By using undeleaved material the ash content of the unbleached pulp was 0.29%. The same pulping conditions were repeated in the pilot plant. The chemical analysis of the resulting pulp was as follows: yield, 37%; alpha-cellulose, 98%; lignin, 1%; wood gum, 1.2%; D.P., 1500 (from copper ammonium viscosity); Johnsen-Noll no. 14. The prehydrolysis conditions used were as follows: 5% H_2SO_4 based on oven-dry material, liquor ratio being 7:1 and 170 min., heating time at a maximum temperature of 125°C. Heating time until maximum temperature was about 60 min. The pulping conditions were as follows: 19.14% NaOH and 4.2% Na_2S based on oven-dry hydrolyzed material; liquor ratio 7:1; maximum temperature, 160°C.; and pulping time at maximum temperature, 180 min. Heating to maximum temperature required 90 min. and cooling from maximum temperature took 30 min. Varying the prehydrolysis and pulping conditions led practically to no effect on ash content but affected mainly the pentosan and alpha-cellulose.

Bleaching and Refining

A multistage bleaching process was used. This consisted of chlorination, hot dilute alkali extraction, and hypochlorite treatment. Two bleached pulps having different D.P. values were prepared. For preparation of bleached pulp no. 1 the following bleaching conditions were applied: chlorination was performed

at 3% consistency by applying 1.1% chlorine based on pulp for 1 hr. at 20°C. In the alkali extraction the consistency of the pulp was 7% and the amount of sodium hydroxide used was 8% based on pulp at 80°C. for 2 hr. In the hypochlorite step 0.3% available chlorine based on pulp was applied at 3% pulp consistency for 2 hr. at 38°C.

solution, the final concentration being 19.6%. A press factor approximately 2.9 was used in all the experiments.

Shredding. The alkali cellulose was shredded in a Pfleidrer shredder to a flocculent mass of looser consistency. The sodium hydroxide content of the alkali cellulose was about 16% and the cellulose content about 30% in all the experiments.

Table I. Analytical Data of Bleached Pulps

Experiment no. →	*1 Laboratory, deleaved*	*1 Laboratory, undeleaved*	*1 Pilot plant, deleaved*	*2 Pilot plant, deleaved*	*Commercial pulps*	
					Normal grade	*High grade*
Yield, %[a]	36	...	34.5	34.5	...	...
Alpha-cellulose, %	96.5	...	97.0	96.5	89.0–92.0	94–96
Furfural, %[b]	2.03	...	...	...	About 4	About 2
Ash, %	0.043	0.12	0.08	0.087	0.04–0.013	0.04–0.08
D.P.	1165	...	1350	865	About 800	Higher than 1000
Brightness, %	83	...	80	90	About 85	About 85

[a] Basis of original material.
[b] Equivalent to approximately 2.8 to 5.6% of pentosan.

The analytical data of this bleached pulp no. 1 which was prepared once in the laboratory and prepared once in the pilot plant are given in Table I.

It is clear that the pulp produced in the pilot plant resembles chemically that produced in the laboratory under the same conditions with the exception of the ash content. This was higher in case of pulping in the pilot plant, possibly due to the use of two different process waters. In other laboratory experiments in which the bleached pulp was obtained from undeleaved material, the ash content amounted to 0.12% in comparison with 0.043% when deleaved material was used.

From this it is concluded that the difficulty of ash in reeds is mainly due to the leaves which contain more ash and silica, especially in an insoluble form than the stems. This has been proved in case of wheat straw by Jayme and Scheuring (*11*). Fahmy and Fadl (*12*) found the same to hold in case of rice straw, which is very rich in ash and silica, and that by removing the leaves, bleached pulp from rice straw with the noteworthy ash content of 0.11% and silica content of 0.07% was obtained. As in case of rice, leaves constitute about 65% of the raw material and since removal of the leaves will be uneconomic, the authors developed a method for removing most of the epidermis cells of the leaves in which the main part of ash and silica is located. In this case the loss corresponded to 12% of the raw material and the resultant bleached pulps contained 0.16% ash and 0.07% silica.

In experiment no. 2, the bleaching conditions were as in experiment no. 1 with the exception of the hypochlorite step in which case 0.8% available chlorine based on pulp was used for 18 hr. at 38°C. The analytical data are given in Table I. From the table it is seen that pulp no. 1 is similar in its chemical composition to the special grades of pulps of high alpha-cellulose and D.P. which are suitable for high tenacity rayon used for tire cords. The bleached pulp no. 2, chemically, represents a normal industrial viscose pulp.

Viscose Preparation for Filter Clogging Constant (K_w) Estimation

Alkalization. The pulp was treated in slurry form at 20°C. for 1 hr. with a concentrated sodium hydroxide

Aging. In this work aging was done under different conditions of temperature and time so as to result in different degrees of oxidation and hence different viscose viscosities to study its effect on the K_w value.

Xanthation or Sulphidation. The carbon disulphide used was about 40% of the amount of cellulose in the alkali cellulose.

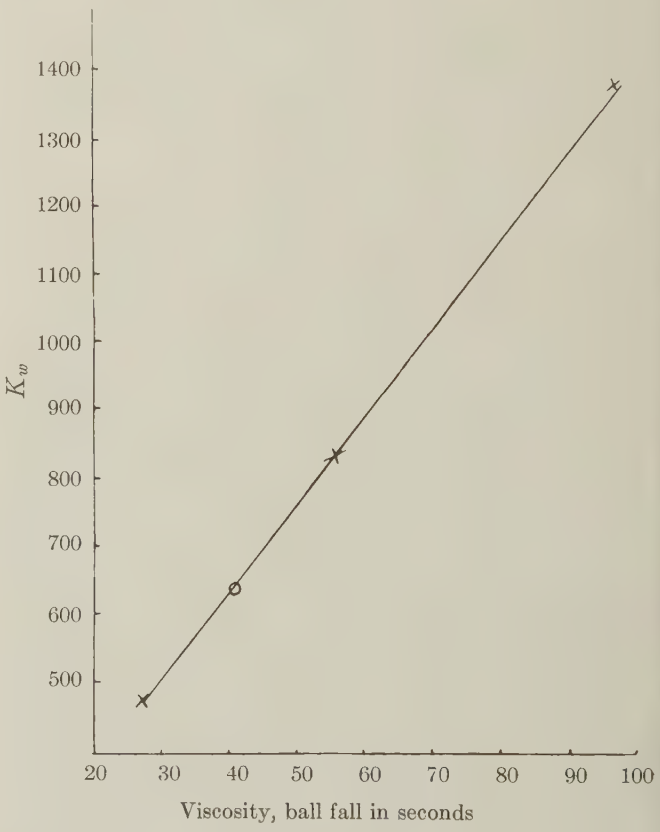

Fig. 1

Viscose Preparation and Estimation of Its Viscosity. The xanthate was dissolved in dilute sodium hydroxide solution so as to deliver viscose containing about 5.6% NaOH and 8.2% cellulose, i.e., the ratio of sodium hydroxide to cellulose was 0.68%. The complete

dissolution took 5 hr. at 14°C. under mechanical stirring. The viscosity of the viscose was estimated by the falling ball method at 20°C. The time taken by a $^1/_8$-in. ball of 131 mg. weight to pass a distance of 200 ml. was recorded.

Estimation of the Filter Clogging Constant (K_w) of the Viscose

The apparatus used for the estimation of K_w was an iron cylinder of about 2.5 l. capacity; the active surface of the filtering material is 8.77 cm. The applied filtration pressure was 2 atm. The filter material was of polyvinyl chloride.

From the bleached pulp no. 2, having a D.P. value of 865, three viscose samples were prepared as described before. All the conditions of the different steps of viscose preparation with exception of the aging was kept practically constant. The conditions of the aging were regulated in each experiment so as to give a different degree of oxidative degradation, i.e., to give at last viscose containing cellulose of different D.P. and hence possessing different viscosities. The viscosity and the K_w of each viscose were measured and the results were: viscosity (ball fall in seconds), 97, 56, 27; K_w 1370, 830, 476, respectively. This shows that the K_w decreased considerably with decreasing viscose viscosity as illustrated by Fig. 1. The straight line relationship seen in the figure cannot be considered to hold between viscosity and K_w without making a great number of measurements which was not the aim of this work. It is clearly seen from these results that the stronger the oxidative degradation in the aging process, i.e., the lower the viscose viscosity, the smaller and hence the better is the K_w value.

In another experiment, a viscose sample was prepared from the bleached pulp no. 1 which possessed the high D.P. value of 1350, the aging time applied was much longer than in the case of the experiment carried out on the low D.P. pulp no. 2, to deliver viscose of approximately the same viscosity. The K_w value was 637 at viscosity of 41 sec. This value fits in the curve of the accompanying diagram. This proved that the oxidative degradation during bleaching of the pulp as well as during the aging of the alkali cellulose has practically the same effect on the K_w of the viscose. In other words, using a high D.P. bleached pulp and applying stronger aging conditions give viscose with the same K_w as in the case of starting with a low D.P. pulp and applying milder aging conditions to deliver viscose containing cellulose with the same D.P.

Viscose obtained from good grades of industrial beechwood pulp had a K_w value of about 400. Viscose from *Phragmites* pulp had a K_w value of 476 at the same viscose viscosity and thus compared well. Viscoses from softwood pulps are of better filterability and possess K_w of about 100.

Preparation of Viscose for Spinning

Two samples of viscose were prepared. For the first sample the aging time was 64 hr. at 18°C. (experiment 1, Table II). In case of the second sample (experiment 2, Table II) 1% H_2O_2 based on pulp was added to the steeping liquor and the aging time was reduced to 16 hr. at 18°C. The amount of carbon disulphide applied for xanthation was 40% of the cellulose content of the alkali cellulose. The viscose composition of experiment 1 was as follows: alkali, 7.2%; cellulose, 8.2%; ratio alkali to cellulose, 0.867. For experiment 2 the values were 6.90%, 8.12%, and 0.850, respectively. The viscose was filtered, allowed to ripen, deaerated and filtered a second time, and then transferred to the spinnerets through the viscose pump. A usual sulphuric acid and sodium sulphate bath was used. The velocity of the take-off on the bobbin was 60 m. for both experiments. In experiments 1a and 2a the filaments were further stretched to a velocity of about 75 m. per min. The rayon filaments were then desulphurized and bleached with sodium chlorite, cleaned, and dried at a temperature range from 60 to 90°C. Both the chemical as well as the mechanical properties of the filaments are found in Table II.

Table II. Test data for viscose solutions and experimental and commercial rayons

Experiment no. →	*1*	*1a*	*2*	*2a*	*Commercial rayon*[a]
Spinning viscosity (falling ball, sec./20°C.)	49	49	60	60	...
Viscose ripening degree, Hottenroth	5.5	5.5	10.1	10.1	...
Single filament fineness in denier	3.80	3.40	4.25	3.28	
Tenacity, g./denier	1.48	1.77	1.57	1.96	about 2.0
Elongation at break, %	23	17	28	25	about 15
Swelling, % (spinning wet)	191	166	137	130	about 150
Swelling, % (after drying)	105	97	103	98	70–100
D.P. (approximate)	290	290	310	310	about 300

[a] Moncrieff, "Artificial Fibres," p. 127, National trade press, 1954. Hermans, "Physics and Chemistry of Cellulose Fibres," p. 194, Elsevier, 1949.

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Spent Sulphite Liquor VII

*Sugar-Lignin Sulphonate Separations Using Ion Exchange Resins**

VINCENT F. FELICETTA, MICHAEL LUNG, and JOSEPH L. McCARTHY

It has been found that the flowing of a spent sulphite liquor over ion exchange resins retained in a column can be conducted so as to bring about a substantial separation of components to yield one solution containing mainly sugars and another solution containing mainly lignin sulphonates. This separation system has been designated as Process PMR 187. Investigations with known compounds have indicated that the separations arise because of the influence to varying degrees of ion exclusion, adsorption, and molecular sieve phenomena. Several experiments with spent sulphite liquors and resins under various conditions have been carried out and others are in progress to ascertain the optimum conditions for carrying out separations.

THE spent sulphite liquors from sulphite pulp mills contain lignin sulphonates and sugars as the two most important components. For utilization of these components for certain purposes such as for the production of industrial alcohol or feed yeast, the lignin sulphonates need not be separated from the sugars. However, for other purposes, substantial advantages may arise if the sugars can be separated economically from the accompanying lignin sulphonates which are present to the extent of about 2.2 to 2.6 times the weight of the sugars.

Several processes for accomplishing the separation have been investigated in this laboratory and investigations are still continuing. Consideration has been given to such methods as dialysis (*1*, *2*), fractionation with amines (*3*), solvent extraction of sugars (*4*), and ion exchange resin processes.

Ion exchange resins may be used in several ways to bring about separation of solution components as pointed out particularly by Bauman and others associated with the Dow Chemical Co. (*5*, *6*). Since spent liquor sugars are nonionic while lignin sulphonates are ionic components, the phenomena of "ion exclusion" is of particular interest as a possible basis for accomplishing the desired separation. Ion exclusion is the name given to describe the fact that an ionic species may exist at only low concentration in a solution situated inside an ion exchange resin particle while the same ionic species may exist at high concentration in the ambient solution outside the resin particle and in equilibrium with it. Apparently, Bauman (*5*, *6*) was the first to point out this phenomenon and to explain it as a case of the Donnan membrane equilibrium. Several discussions of the theory and the application of ion exclusion have been published (*7–11*) and some of these papers have dealt with the separation of mixtures of ionic from nonionic substances, and of strongly ionized from weakly ionized substances.

The experiments reported in this paper demonstrate that spent sulphite liquor sugars can be separated quite effectively from lignin sulphonates by use of ion exchange resins.

EXPERIMENTAL

Ion Exchange Resins

Experiments were carried out using the polystyrene nuclear sulphonate cation exchange resin Dowex 50 with 8 or 4 or 1% divinyl benzene crosslinking (Dow Chemical Co., Midland, Mich.). The X8 resin was 50 to 70 mesh size and the X4 and X1 resins were 50 to 100 mesh size.

In some experiments, the resins were used as received in the hydrogen form after thorough washing with distilled water. In other cases the sodium or calcium form was used and this was prepared by treating the hydrogen resin with an aqueous solution of 5% NaCl or 5% aqueous $CaCl_2$, respectively, followed by thorough washing with distilled water. The cation affixed to the resin was the same as that in the feed solution to be separated.

The resins were contained in vertical Pyrex glass columns of three general sizes: column A-500 cm. high, 2.8 cm. i.d.; column B-200 cm. high, 2.9 cm. i.d.; and column C-100 cm. high, 2.2 cm. i.d. Volumes of resin beds used in specific experiments appear in Tables I and II.

Table I. Ion Exchange Resin Column Systems and Experimental Conditions[b]

Resin column systems[a]								
Column no.	*Cross linking*	*Salt*	V_F, *ml.*	V_L, *ml.*	V_R, *ml.*	V_T, *ml.*	*Flow, ml./min. per sq. cm.*	*Expt.*
A	8X	Ca	10	845	1267	2815	0.09	24, 25
B	4X	Ca	5	299	515	1030	0.15	1530
C	8X	H	10	92	128	305	0.27	1, 4[c]
C	1X	Ca	3	100	181	312	0.18	153D
C	1X	H	3	91	207	313	0.17	153E

[a] In Table II and elsewhere the first resin column system is designated as A-8X-Ca indicating that experiments 24 and 25 were conducted with resin column A consisting of Dowex 50 resin with a crosslinking index of 8X and with the resin sites as calcium salts = Ca, etc.

[b] V_F = volume of feed solution, V_L and V_R are the volumes of solution outside and inside the resin particles in the column, V_T is total volume of the resin bed, and "Flow" designates eluent flow rate in milliliters per minute per square centimeter area of column cross section.

[c] Resin column system C-8X-H was also used in experiments 7, 8, 10, 11, 13, 14, 15, 17, 18, 20, and 21.

Reagents and Materials

Spent Sulphite Liquors. Two batches of steam stripped calcium spent sulphite liquor were kindly provided by E. O. Ericsson of the Puget Sound Pulp &

* The prior paper of this series was published as *Tappi* 37: 431 (1954). VINCENT F. FELICETTA, Research Assistant Professor, MICHAEL LUNG, present address: Atomic Energy Organization, Paris, France, and JOSEPH L. MCCARTHY, Professor, University of Washington, Seattle, Wash.

Timber Co. at Bellingham, Wash. These liquors were used (a) as received at 11.5% total nonvolatile solids content or (b) as a concentrate solution containing about 18% solids prepared by evaporation at reduced pressure below 50°C. or (c) as sodium salts, or (d) as the free acids prepared by appropriate ion exchange. The particular state of each liquor studied is indicated in Tables I and II.

For certain experiments, 4 l. of the (a) concentrated CaSSL containing 18% solids was extracted three times using n-butanol containing 5% water in volumes of 1600, 500, and 600 ml. giving n-butanol extracts of 650, 550 and 600 ml. volumes, respectively. The butanol extracts were combined and the precipitated calcium sulphate was filtered off. The butanol-saturated and extracted aqueous spent sulphite liquor remained as a clear solution.

Known Substances. The following chemicals were used in the preparation of aqueous solutions: guaiacol (U.S.P. grade, purified by distillation *in vacuo*); acetovanillone, (technical grade, kindly provided by Monsanto Chemical Co., Seattle, Wash.); d-glucose (C.P. grade), all other sugars (Eastman "White" label), methyl ethyl ketone (Eastman practical grade); sodium-*p*-phenolsulphonate (Eastman "White" label, purified by recrystallization); vanillic acid, (technical grade, purified by recrystallation); vanillin (Eastman "White" label); and C.P. grade acetic, formic, hydrochloric, and oxalic acids.

Analytical Methods

Acetovanillone, guaiacol, methyl ethyl ketone, sodium-*p*-phenol sulphonate, vanillic acid, and vanillin were determined quantitatively by ultraviolet absorption measurements using a Beckman Model DU spectrophotometer. Calcium and sodium lignin sulphonates were also determined in this manner by taking observations using 280 mmu radiation. Additional absorption measurements on lignin sulphonates at 255 to 260 mmu and also at 310 mmu were taken and used to compute absorbance ratios from which rough estimates of molecular weight were obtained (*12*).

Sugars and/or reducing substances were determined by a modified Munson and Walker procedure.

Lignin sulphonic acids for experiments 302 and 304 were determined by titration with standard sodium hydroxide solution to the phenolphthalein end point. In other experiments the acids, acetic, formic and hydrochloric, were also determined by titration with standard base.

The n-butanol concentration was estimated by the drop method for surface tension.

Procedure for Conducting a Separation Experiment

For column preparation a known weight of moist resin was slurried in distilled water, poured into a Pyrex glass column, and allowed to settle. The resin was retained in the column by use of a plug of glass wool and the flow was controlled by use of capillary tubing joined to the bottom by use of a short section of rubber tubing. The hydrogen resin was converted to sodium resin or calcium resin by passage of 5% sodium chloride or calcium chloride solution until the effluent was free of acid. The final step in column preparation was washing with distilled water to remove soluble resin components and also regenerant solution if this had been used.

For separations, the liquid in the column was drained down until its surface was at the bed level and then the sample was added to the resin column. The sample was allowed to percolate through the bed at a known and fixed flow rate until the level of the liquid surface came down to bed surface level and then three small increments of distilled water were added with drainage to bed surface level after each addition. Thereafter, a reservoir of distilled water was placed on top of the bed in a "chicken-feeder" arrangement. Incremental volumes

Table II. Ion Exchange Resin Column Experiments with Known Substances and CaSSL Sugars

Expt. No.	Column system	Substance	Operational data: C_F, mg./ml.	$V_{max.}$, ml.	W, ml.	$C_{max.}/C_F$	Distn. coef.: C	Distn. coef.: K_D	No. plates: P_M	No. plates: P_S	Ht. plates: H_M, cm.	Ht. plates: H_S, cm.
1	C-8X-H	Hydrochloric acid	53	135	14	0.44	1.5	0.34	377	313	0.21	0.26
		Methyl ethyl ketone	49	355	29	0.19	3.9	2.05	345	73	0.23	0.11
4	C-8X-H	d-Glucose	50	143	11	0.47	1.51	0.38	376	680	0.21	0.12
14	C-8X-H	d-Mannose	50	153	11	0.47	1.61	0.44	614	751	0.13	0.11
4, 13	C-8X-H	dl-Xylose	50	160	11	0.47	1.68	0.48	450	674	0.18	0.12
15	C-8X-H	d-Galactose	50	163	11	0.47	1.71	0.71	805	695	0.10	0.12
4	C-8X-H	l-Arabinose	50	205	11	0.47	2.16	0.83	680	855	0.12	0.09
11	C-8X-H	Oxalic acid	50	153	17	0.35	1.61	0.45	228	263	0.35	0.30
10	C-8X-H	Formic acid	50	192	16	0.35	2.01	0.75	461	356	0.17	0.22
8	C-8X-H	Acetic acid	50	215	20	0.35	2.26	0.94	400	334	0.20	0.24
24	A-8X-Ca	d-Xylose	25	1572	55	0.082	1.65	0.52	7100	2610	0.27	0.18
		l-Arabinose	25	1917	61	0.060	2.00	0.81	4860	2860	0.37	0.16
25	A-8X-Ca	CaSSL sugars	43	1507	50	0.025	1.58	0.47	..	2975	...	0.15
				1558	32	0.029	1.63	0.51	...	7200	...	0.06
				1701	100	0.118	1.79	0.64	5270	912	0.09	0.05
7	C-8X-H	n-Butanol	78	395	23.5	...	4.15	2.36	...	700	...	0.11
20	C-8X-H	Guaiacol	1	1120	80	0.027	11.8	8.0	356	425	0.22	0.19
18	C-8X-H	Vanillic acid	1	1185	180	0.027	12.5	8.5	69	94	1.16	0.85
17	C-8X-H	Vanillic	1	2375	264	0.027	25.0	17.8	298	168	0.27	0.48
21	C-8X-H	Acetovanillone	1	2600	195	0.027	27.4	19.6	122	379	0.65	0.21
22	C-8X-H	Acetovanillone	1	2785	220	0.027	29.3	22.8	159	332	0.50	0.24
153C	B-4X-Ca	Na-*p*-phenol sulphonate	10	435	35	0.079	1.36	0.23	490	535	0.13	0.12
153D	C-1X-Ca	Na-*p*-phenol sulphonate	10	166	18	0.085	1.87	0.43	204	261	0.16	0.12
153E	C-1X-H	Na-*p*-phenol sulphonate	10	123	10	0.125	1.37	0.16	435	433	0.07	0.08

of the column effluents were collected by use of an automatic sampling table and then analyzed by the above described methods.

Partition Coefficient Studies

The equilibrium distribution of a solute between the solution and resin phases may be expressed as the usual partition coefficient,

$$K_D = \frac{C_R}{C_L} = \frac{V_M - V_L}{V_R} \qquad (1)$$

or as the mass partition coefficient,

$$C = V_M/V_L \qquad (2)$$

where: C_L, V_L, and C_R, V_R refer to concentration of solute and volume of solution in the column outside and inside the resin particles, respectively, and V_M is the volume of eluent collected up to the maximum solute concentration.

For resins of 50 to 100 mesh in particle size, Wheaton and Bauman (*9*) reported values of 30 and 42% of bed volume for V_L and V_R, respectively, for Dowex 50-8X-H^+ resin, and 30 and 45% of bed volume for V_L and V_R, respectively for Dowex 50-8X-Na^+ resin. Using similar experimental techniques, the present authors found for V_L and V_R for Dowex 50-X4-Ca^+ resin, Dowex 50-X1-Ca^+ resin, and Dowex 50-X1-H^+ resin, the following respective percentages of bed volumes: 29 and 50; 32 and 58; and 29 and 66.

Values of V_M were obtained experimentally from elution curves. Columns used for these measurements were standardized at a resin bed height of 80 cm. and a diameter of 2.2 cm. to give, usually, a total bed volume of 305 ml. The same general column preparations given above were followed here also. The flow rate used in this work was closely controlled usually at 1 or 0.26 ml. per sq. cm. per min., which is presumably low enough to yield approximate equilibrium distribution of solutes between inner and outer solutions. Resin beds of Dowex 50-X8-HCR, Dowex 50-X1-HCR and Dowex 50-X1-CaCR were used for studies with several known substances as shown in Table I. Two experiments were carried out with the Dowex 50-X1-CaCR using calcium spent sulphite liquor as noted in Table II.

Evaluation of Column Performance

Mayer and Tompkins (*13*) have given a theoretical treatment for column separation processes. In their nomenclature,

$$L_{max.} = \frac{1}{[2\pi PC(1 + C)]^{1/2}} \qquad (3)$$

where: $L_{max.}$ = fraction of solute in any plate volume, v, of solution at the maximum of the elution peak; P, the number of theoretical plates; C, the mass partition coefficient of solute distribution between the solution and the resin or adsorbent phase in a plate. Equation (3) is valid only for large numbers of plates since Stirling's approximation was used in the derivation.

If we let m equal mass of solute added to the column in milligrams, $c_{max.}$, milligrams solute per milliliter at maximum concentration of a component in the eluate, and V_L, the volume of liquid outside the resin particle which is equal to the column volume and thus to Pv. Then:

$$L_{max.} = \frac{(c_{max.})(v)}{m} = \frac{(c_{max.})(V_L)}{(m)(P)} \qquad (4)$$

$L_{max.}$, given in equation (4), can be substituted in equation (3) which reduces to the following equation for the number of plates:

$$P = 2\pi(1 + C)(C)\left[\frac{(c^2_{max.})(V^2_L)}{m^2}\right] \qquad (5)$$

For calculation of number of plates from equation (5), there is needed the mass partition coefficient given by equation (2), the concentration of solute at the maximum, $c_{max.}$, the amount of solute added, m, and the column volume, V_L.

A simpler method for calculation of the number of plates was formulated by Mayer and Tompkins (*13*) based upon the assumption that a normal probability curve sufficiently closely approximates the elution curve and this equation is:

$$t = \frac{P^{1/2}(F - C)}{[C(1 + C)]^{1/2}} \qquad (6)$$

where: t is the sigma unit and F the number of column volumes to a particular value for t in the elution curve.

Equation (6) can be expressed in terms of a fixed value for t thus eliminating the need for reference to the tables of the probability function. By squaring both sides of equation (6), and solving for P, one obtains:

$$P = \frac{t^2C(1 + C)}{(F - C)^2} \qquad (7)$$

The numerical value of the sigma unit, t, at $1/\epsilon$ of the maximum of the elution curve is 1.414 and substitution of this into equation (7) gives:

$$P = \frac{2C(1 + C)}{(F - C)^2} \qquad (8)$$

where "$F-C$" is the number of column volumes of half width of the elution curve at an ordinate value of $1/\epsilon$ of the peak concentration.

In the terminology of Simpson and Wheaton (*14*), equation (8) is:

$$P = \frac{2V_M(V_M + V_L)}{W^2} \qquad (9)$$

where: $F-C = W/V_L$ and W is the volume of half width of an elution peak at an ordinate value of $1/\epsilon$ of the peak concentration. However, equation (9) differs from the similar but apparently incorrect equation reported in the paper by Simpson and Wheaton as suggested by L. A. Matheson (*14*).

Using equations (8) or (9) the numbers of column plates obtained in the several experiments have been computed from the elution curves and by proceeding in this manner it was not necessary to establish the amounts and concentrations of solutes in the feed solution, nor the absolute concentrations of solute at the peak in the elution curve.

DISCUSSION

Experiments were conducted with several pure substances with various ion exchange resin column systems and the column conditions used as summarized in Table I. The symbols are defined when introduced in the text. In a particular experiment, one or more solutes were

used as shown in Table II. From the elution curves, values of $V_{max.}$, W, and $C_{max.}/C_F$ for each solute were secured and then computations were made of the partition coefficients, C and K, and of the apparent number of plates by equation (5) according to Mayer and Tompkins, P_M, and by equation (9) according to Simpson and Wheaton, P_S, and also of the corresponding column heights per plate, H_M and H_S.

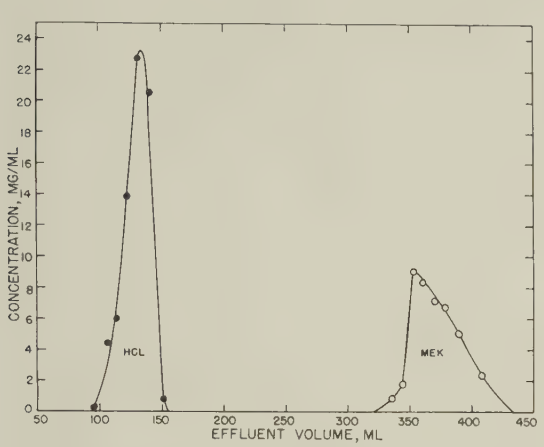

Fig. 1. Ion exchange resin column separation of hydrochloric acid from methyl ethyl ketone

Experiment 1 was conducted with hydrochloric acid and methyl ethyl ketone as solutes in aqueous solution (Fig. 1). The distribution coefficient found for hydrochloric acid was about 0.34 showing "ion exclusion" in that this ionic substance does exist at much lower concentration inside the resin particle than outside the particle. For the hydrochloric acid, the number of plates was of the same order of magnitude as estimated by the two computations, i.e., 377 and 313, and the average column height per plate 0.21 and 0.26. Similar relationships prevailed for most of the other cases studied.

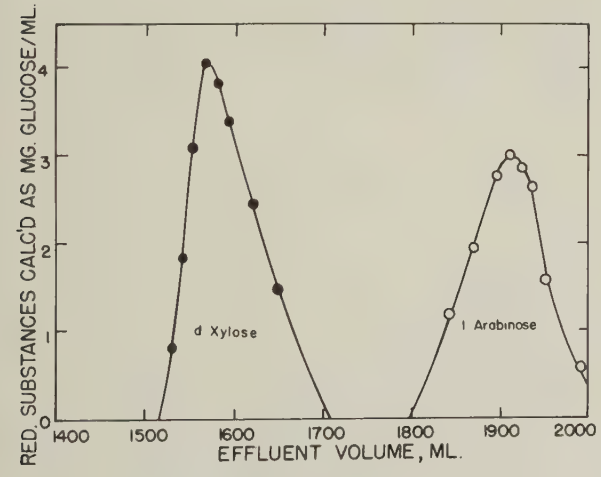

Fig. 2A. Elution curve for a known mixture of d xylose and l arabinose

Methyl ethyl ketone showed a distribution coefficient of about 2.0 and the higher concentration prevailing inside the particle probably results from selective adsorption of this substance on the polymer network of the resin. The estimated number and height of Mayer and Tompkins plates agreed roughly with the results found for hydrochloric acid.

The next several experiments were conducted using several monomeric sugars (Fig. 2) which occur as components of the spent sulphite liquor sugar fraction. The

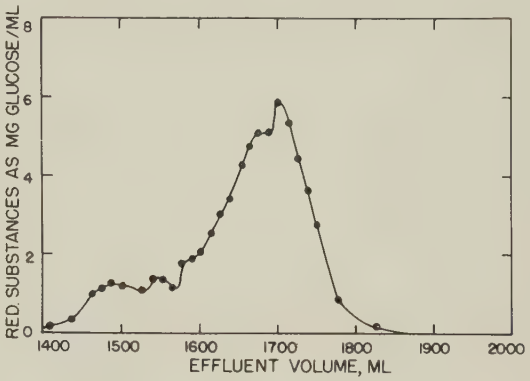

Fig. 2B. Elution curve for sugars from calcium spent sulphite liquor

observed distribution coefficients range from 0.38 to 0.83. Since the sugars are not ionic substances, it appears that these low distribution coefficients could arise in part by a "molecular sieve" action, i.e., a certain fraction of the resin passages may be too small to permit entrance of the sugars and yet large enough to permit entrance of water and other relatively small molecules. Differences in the distribution coefficients for the several sugars with the same resin may thus reflect differences in the size and shape of the sugar molecules although a direct molecular weight relationship is not evident. Distribution coefficients for oxalic, formic, and acetic acids were found to be 0.45, 0.75, and 0.94 which is the order of "ion exclusion" expected from consideration of ionization constants which are 6.5×10^{-2}, 1.76×10^{-4}, and 1.75×10^{-5}, respectively. With the substances n-butanol, guaiacol, vanillic acid, vanillin, and acetovanil-

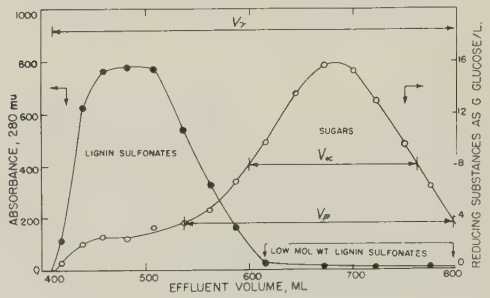

Fig. 3. Ion exchange resin column fractionation of spent sulphite liquor

lone distribution coefficients values were more than one in all cases, and much more than one for the phenols indicating adsorption effects. However, with sodium phenol sulphonate, which ionizes extensively, the distribution coefficients found were in the range of 0.16 to

Table III. Ion Exchange Resin Column Experiments with Spent Sulphite Liquors

Expt. No.	Column[a] system	SSL feed	Feed: Components	Feed: Mass, g.	Feed: C_F, g.p.l.	Operational data: $V_{max.}$, ml.	Operational data: W, ml.	Operational data: $C_{max.}$	Part. coefs.: C	Part. coefs.: K_D	Plates: P_S	Plates: H_S
302	8X-H-159-6.6	11% HSSL	LS	...	...	420	40	...	1.25	0.17	396	0.40
			Sugars	...	...	527	65	...	1.58	0.44	215	0.74
304	8X-H-457-6.2	7.5% HSSL	LS	...	...	1000	110	...	1.05	0.17	325	1.40
			Sugars	3.4	16.95	1327	130	13.0	1.38	0.35	363	1.26
303	8X-Na-164-6.6	10% NaSSL	LS	...	...	400	68	...	1.21	0.15	127	1.29
			Sugars	3.7	22.6	580	78	16.3	1.75	0.56	174	0.94
305	8X-Ca-170-6.6	11.5% CaSSL	LS	...	...	485	60	...	1.15	0.13	244	0.70
			Sugars	3.5	26.25	675	95	14.3	1.86	0.49	164	1.04
309	4X-Ca-150-6.6	11.5% CaSSL	LS	6.6	60	385	62	51.5	1.28	0.23	137	1.10
			Sugars	2.9	26.3	680	88	15.0	2.26	1.02	172	0.87
5	1X-Ca-80-3.8 (new)	11% CaSSL	LS-1	0.41	[69.5]	125	175	38.4	1.47	0.38	172	0.57
			LS-2	0.28		233	21	9.6	2.74	1.41	337	0.15
			Sugars	0.50	25	259	110	17.0	3.05	1.66	494	0.16
23	1X-Ca-80-3.8 (used)	10% CaSSL	LS-1	0.43	[69.5]	120	23	10.0	1.48	0.39	91	0.88
			LS-2	0.28		210	26	6.0	2.59	1.29	180	0.44
			Sugars	0.50	24.5	256	24	10.0	3.16	1.75	299	0.27
6	8X-Ca-457-6.2	18% CaSSL	LS	52.2	104	1350	150	100	1.43	0.33	243	1.88
			Sugars	20.6	41	1850	140	37.2	1.93	0.75	530	0.86
			BuOH	...	...	2725	150	...	2.86	1.49	891	0.51
9	8X-Ca-457-6.2	18% CaSSL	LS	25.0	99	1260	160	85.5	1.32	0.25	218	2.09
			Sugars-1	4.8	[41]	1700	90	26.5	1.78	0.63	1115	0.40
			Sugars-2	5.3		1840	115	28.0	1.92	0.76	778	0.59
			BuOH	...	...	2690	130	...	2.82	1.47	1169	0.39
12	8X-Ca-457-6.2	18% CaSSL	LS	31.0	98.5	1230	110	88.0	1.42	0.25	446	1.02
			Sugars	12.9	41.5	1800	220	27.2	1.88	0.77	206	2.21
			BuOH	...	...	2720	215	...	2.85	1.49	437	1.04

[a] For experiment 302, for example, the column system designation of 8X-H-159-6.6 signifies use of Dowex 50 resin, with an 8X crosslinking index, in the free acid or H form, and when the column is 159 cm. high and 6.6 sq. cm. in cross-section area, etc.

0.43, thus showing the predominance of the ion exclusion over the adsorption effects under the circumstances used.

These illustrative results indicate that the behavior of a solute in an ion exchange resin column is influenced by three mechanisms, i.e., ion exclusion, adsorption, and molecular sieve exclusion. With other resins or solutes or solvent systems, other results are to be expected.

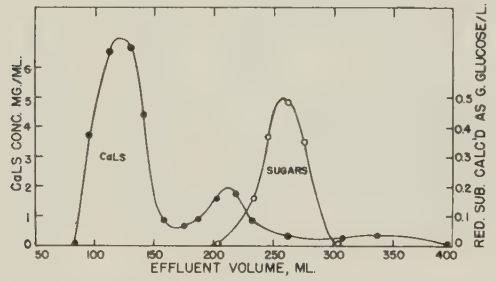

Figure 4. Ion exchange resin column fractionation of stripped CaSSL with Dowex 50-X1 CaR

Separations of spent sulphite liquor components into lignin rich fractions and sugar rich fractions have been conducted using two different spent sulphite liquors and a variety of ion exclusion operating conditions which are summarized in Table II along with the results of computations. Figure 3 is the elution curve for a calcium spent sulphite liquor showing a high degree of separation of lignin sulphonates from sugars using the conditions given in Table III for experiment 305. This type of a separation process is being designated as Process PMR 187 and efforts are being made to find the optimum way to conduct practical separations.

Examination of the data in Table III shows that experiments were carried out to investigate in a preliminary way the effects of (a) form of the resin and the spent liquor, i.e., hydrogen versus sodium versus calcium; (b) resin crosslinking such as 8 versus 4 versus 1% divinylbenzene; (c) spent sulphite liquor total solid concentration; (d) flow rate; and (e) volume of spent sulphite liquor feed. Estimates of the numbers of theoretical plates have been made using equation (9) knowing the void volume of the resin bed, V_L, and the position and width of an elution peak. The theoretical plate heights are seen to be mostly higher and more variable than those found for known pure substances because the elution peaks from a separation experiment with spent sulphite liquor are not those of individual substances but rather of mixtures.

With respect to crosscontamination, estimates of concentration of sugars by analyses for reducing substances include also the effects of the reducing power associated with the lignins. Thus the actual amounts of sugars which contaminate the bulk of the lignin sulphonates are somewhat less than indicated from the total reducing substances in Figs. 3 and 5.

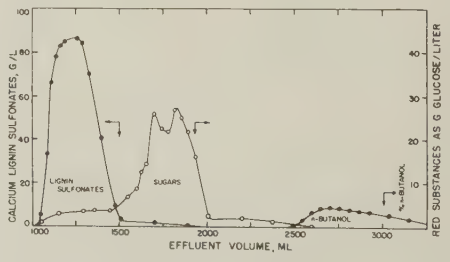

Fig. 5. Ion exchange resin column fractionation of butanol spent sulphite liquor

Estimates of the concentrations of lignin sulphonates

were made by ultraviolet absorption measurements and Figs. 3 and 5 show a small proportion of lignin sulphonates in samples containing predominantly sugars. This lignin sulphonate material eluted from about 600 to 800 ml. in experiment 305 as shown in Fig. 3 was combined and was found to show a diffusion coefficient of 41.0 sq. mm. per day indicative of an average molecular weight of about 500 whereas the whole lignin sulphonate material in the spent sulphite liquor feed showed a diffusion coefficient of 17.5 sq. mm. per day indicating an average molecular weight of about 10,000. Thus, the lignin sulphonates which contaminate the sugars are of low molecular weight and investigations of these lignins in this laboratory have shown them to be comprised mostly of monomeric and dimeric moieties of molecular size expected for the structural units of the lignin polymer (*15, 16*).

For establishment of cost indices for producing crude sugars and lignin sulphonates by ion exchange resin processing under various conditions, the following preliminary calculations have been made assuming batch operation of the resin columns under the various Table II conditions to obtain solution increments V_α, V_β, and V_γ as indicated in Fig. 3 where: V_α = volume of solution from 50% of the maximum sugar concentration to the maximum and then back to 50% again; V_β = volume of sugar solution from 20% of maximum on rising side to 20% on the falling side; and V_γ = total volume necessary for elution of both lignin sulphonates and sugars or the total cycle volume. Graphical integration has been used to establish s_α and s_β = the grams of reducing substances calculated as glucose produced per cycle in increments V_α and V_β. From the known feed of reducing substances in one cycle, the percentage of

Table IV. Estimated Cost Indexes for Sugar-Lignin Sulphonate Separations Using Ion Exchange Resins by Process PMR 187

Result \ Factors / Expt. No.	Varying bases			Varying resin crosslinking			BuOH extd. 18% conc.		
	304	303	305	309	5	23	6	9	12
Feed SSL and Resin Column Characteristics									
SSL base	H	Na	Ca	Ca	Ca	Ca	Ca	Ca	Ca
Resin type	8X	8X	8X	4X	1X	1X	8X	8X	8X
h, cm.	457	164	170	150	80	80	457	457	457
A, sq. cm.	6.2	6.6	6.6	6.6	3.8	3.8	6.2	6.2	6.2
hA, cu. cm.	2820	1080	1120	970	305	305	2820	2820	2820
v, cm./min.	0.65	0.60	0.60	0.60	0.26	0.26	0.30	0.26	0.81
vA, cu. cm./min.	5.0	4.0	4.0	4.0	1.0	1.0	2.0	1.6	5.0
N_γ cycles/day	9.6	11.5	12.5	8.7	4.8	4.8	1.1	0 9	2.7
Volumes of Cuts and Cycles									
V_α, cu. cm.	200	130	160	150	30	50	430	300	300
V_β, cu. cm.	285	190	300	250	60	85	800	450	620
V_γ, cu. cm.	700	500	450	600	200	200	2600	2600	2650
Sugar Yields									
s_α, g.	2.12	1.86	1.84	1.85	0.156	0.179	14.8	7.3	9.05
s_β, g.	2.48	2.16	2.50	2.35	0.342	0.233	19.3	9.2	12.6
Sugar Concentration in Cuts									
C_α, g.p.l.	10.7	14.3	12.8	12.4	5.2	3.6	34.5	24.4	30.0
C_β, g.p.l.	8.7	11.4	8.3	9.5	5.7	2.7	24.0	20.4	20.3
Sugar Recoveries in Cuts									
μ_α, %	82	83	71	75	63	73	77	72	85
μ_β, %	96	97	96	95	94	95	95	91	92
Contamination in Sugar Cuts (g. LS/g. Sugar)									
l_α, g./g.	0.18	0.12	0.07	0.11	0.26	0.28	0.04	0.05	0.04
l_β, g./g.	0.17	0.10	0.44	0.15	0.24	0.39	0.15	0.05	0.12
Sugar Production Rate Per Unit Resin									
S_α, lb./(yr.)(cu. ft.)	135	372	386	345	43	50	185	44	163
S_β, lb./(yr.)(cu. ft)	157	432	525	392	95	65	142	55	227
Resin Cost Index									
$C'_{r\alpha}$, ¢/lb.	5.9	2.3	2.7	2.3	18.6	16.0	4.3	18.3	4.9
$C'_{r\beta}$, ¢/lb.	5.1	1.9	1.5	2.0	8.5	12.3	5.6	14.6	3.5
Evaporation Cost Index									
$C'_{e\alpha}$, ¢/lb.	1.1	0.5	0.7	0.8	4.8	7.00	0.0	0.0	0.0
$C'_{e\beta}$, ¢/lb.	1.6	1.0	1.75	1.4	4.4	9.13	0.0	0.0	0.0
Total Cost Index									
C_α, ¢/lb.	6.0	2.8	3.4	3.1	23.4	23.0	4.3	18.3	4.9
C_β, ¢/lb.	6.7	2.8	3.3	3.4	12.8	21.4	5.6	14.6	3.5

reducing substance recovery can then be estimated as r_α or r_β. The average concentration of reducing substances is also estimated as $\bar{C}_\alpha = s_\alpha/V_\alpha$ and $\bar{C}_\beta = s_\beta/V_\beta$. The grams of lignin sulphonates present in volume increments V_α and V_β are roughly calculated by graphical integration to obtain absorbance milliliters = (A) (ml.), and then dividing by (13.4) (1000) since by the Beer's law relationship absorbance $= A = alc$ where: a is the absorptivity which is assumed to be 13.4 l. per g. cm. for calcium lignin sulphonates; l the length of light path = 1 cm.; and c is the concentration in grams per liter. The ratio of weight of lignin to weight of sugar, l_α and l_β, indicates the degree of contamination of sugars by lignin sulphonates.

From the known liquid flow rate through the bed, v, cu. cm. per (min.) (sq. cm.), and from the cross-sectional area of the bed, A, the volumetric flow rate is obtained as (v) $(A.)$ cm.^{3} per min. The time per cycle, θ, is V_γ/vA min. per cycle or $(1440vA)/V_\gamma = N_\gamma =$ number of cycles per day. Thus the reducing substance production in pounds per year of 300 days would be $300\ s_\alpha N_\gamma/454$ and $300\ s_\beta N/454$. From the known height of the bed, h, the volume of the bed, hA cu. cm. of $hA/28{,}400$ cu. ft., is obtained so that there can be calculated the pounds of reducing substances produced per year per cubic foot of resin bed, e.g.,

$$S_\alpha = \left(\frac{300 s_\alpha N_\gamma}{454}\right)\left(\frac{28{,}400}{hA}\right) = \frac{\text{lb. reducing sugars}}{\text{(year)(cu. ft. resin)}} \quad (10)$$

If the resin is estimated to cost \$20 per cu. ft., and if total cost instrumented, etc. is arbitrarily taken as twice this number or \$40 per cu. ft., and if it is assumed that this cost must be amortized in 5 years, then the resin cost index for the sugar solution in cents per pound of sugar $C'_{r\alpha}$, will be

$$C'_{r\alpha} = \frac{(8)(100)}{S_\alpha} \quad (11)$$

However, since the sugar solutions from the several experiments are at different concentrations, it seems better to compare the cost indices at a standard concentration, which was taken arbitrarily to be 20 lb. sugar per 1000 lb. water. The water present in a particular fraction is approximately equal to

$$\frac{1}{\bar{C}_\alpha} = \frac{V_\alpha}{s_\alpha} = \frac{\text{lb. water}}{\text{lb. reducing substance}} \quad (12)$$

so that the water to be removed is about

$$\left[\frac{1}{\bar{C}_\alpha} - 50\right] = \frac{\text{lb. water}}{\text{lb. reducing substance}} \quad (13)$$

If now it be assumed that the cost of removing this water is 0.025¢ per lb., then the evaporation cost index, $C'_{e\alpha}$, may be

$$C'_{e\alpha} = 0.025\left[\frac{1}{\bar{C}_\alpha} - 50\right] = \frac{\text{cents cost of water removal}}{\text{lb. reducing substance}} \quad (14)$$

Adding the evaporation cost index to the resin cost index gives an estimated total cost index for production of the sugar solution at a standard concentration in terms of cents per pound of reducing substance, C_i, as:

$$C_\alpha = \left[\frac{(8)(100)}{S_\alpha}\right] + 0.025\left[\frac{1}{\bar{C}_\alpha} - 50\right] \quad (15)$$

and, of course, this cost index must be considered with account taken of the contamination as indicated by the different lignin-sugar ratios.

The calculated results for the several experiments are summarized in Table IV. Cost indices for producing a 2% sugar solution are found to range from 3 to 5¢ per lb. of sugar using either Dowex 8X or Dowex 4X resin in the sodium or calcium form although in experiment 9 the much reduced flow rate of course results in very high resin cost indices. The use of Dowex 1X calcium resin (experiments 5 and 23) yields relatively high cost indices as well as high degrees of contamination of sugars by lignin sulphonates. Treatments to remove the low molecular weight lignin sulphonates by extracting spent calcium sulphite liquor with butyl alcohol prior to the column separation (experiments 6, 9, and 12) resulted in a reduction of lignin contamination to the level of about 4 or 5% of the sugar.

Experiment 305 with calcium spent sulphite liquor and Dowex 8X resin gave one of the best results. Thus here the sugar production amounted to nearly 400 lb. of reducing substances per year per cubic foot of resin, the contamination was equivalent to about 7 lb. of lignin sulphonates per 100 lb of sugar, the dilution was less than in most other cases studied, and the total cost index was found to be about 3¢ per lb. of apparent sugar.

The cost indices shown in Table IV are only relative but they serve to emphasize the importance of the initial cost and the life of the resin per unit sugars and lignin sulphonates processed. If the resin life should be twice as long as assumed, then the resin cost index would be halved. To minimize resin costs, it is possible that an ion exchange resin prepared from lignin sulphonates might be used along with a continuous countercurrent resin processing system and these and other prospects such as the concentration effects of recycling (*17*) are being investigated in studies which are continuing in this laboratory.

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Spent Sulphite Liquor VIII

Fanning Friction Factors and Heat Transfer Coefficients for Concentrated Spent Sulphite Liquors

LARS GRIMSRUD and JOSEPH L. McCARTHY

Friction factors and heat transfer coefficients have been measured for steady state pipe flow of magnesium-base spent sulphite liquors at concentrations up to nearly 60% solids and at wall temperatures in the range of about 200 to 260°F. The test section of the heat exchanger consisted of a 304 stainless steel smooth pipe 3/4 in. in nominal diameter and about 8 ft. long. Mean flow rates through the test section were 3 to 18 f.p.s. The fluid was found to be Newtonian and to give the usual Fanning friction factors within the range investigated. The experimental heat transfer coefficients were found to be roughly in the range of those predicted by the Sieder and Tate equation.

MANY processes have been proposed for treating spent sulphite liquors to accomplish recovery of useful products or of heat and process chemicals (*1*). In most of these processes, the heating and cooling of the liquor is a necessary step so the design of heat exchange equipment for this purpose is perhaps of some general interest.

Spent sulphite liquors, as usually obtained, contain solids to the extent of about 10 w. %, and these solids, consists predominantly of lignin sulphonates and sugars. The viscous behavior of such dilute solutions is quite similar to water and, apart from possible scale-formation corrosion problems, the design of heat interchanger equipment may be carried forward using the usual relations for estimation of friction factors and heat transfer coefficients (*2*). However, for spent sulphite liquors containing solids at higher levels of concentration and of higher viscosities, some measure of doubt seems justified as to the applicability of these usual equations. There is evidence that some solute lignin sulphonate molecules are relatively high in molecular weight (*3, 4*) and molecules of this type in solution may give rise to non-Newtonian behavior (*5*).

In the literature some values have been reported of heat transfer coefficients for boiling spent sulphite liquors (*6–8*) but no data seem to be available on nonboiling coefficients for liquors of high viscosity or high Prandtl numbers. Thus, the present investigation (*9*) was carried out to obtain experimental data on the fluid friction and heat transfer characteristics of sulphite spent liquors containing solids at relatively high concentrations, and also to compare the experimental results obtained with those predicted by the usual pressure drop and heat transfer equations.

NEWTONIAN CHARACTERISTICS OF THE SPENT SULPHITE LIQUORS

Experiments were conducted using a magnesium spent sulphite liquor containing 57.8 lb. of nonvolatile solids per 100 lb. of solution (57.8%) kindly provided by Paul Billington of the Research Laboratory of the Weyerhaeuser Timber Co., Longview, Wash. For some experiments this liquor was diluted with water to provide solutions of 49.5 and 45.3 wt. % solids concentration.

The viscous behavior of these three liquors was investigated at various shear rates using a MacMichael viscometer (*10*) which is of the Couette rotating disk type (*11*). The radius of the viscometer cup was 3.6 cm. and the bob was 4.9 cm. high; the bob radius was 1.2 cm. and 1.9 cm. for the experiments represented in Figs. 1 and 2, respectively. Experiments were conducted at 23 ± 1°C. with several rates of cup rotation and the results in terms of relative values of torque versus cup rotation rates are plotted in Figs. 1 and 2. Calculation of the velocity gradients corresponding to these cup rotation rates can be made by use of equation (1):

$$\frac{dv}{dy} \approx \frac{(R.P.M.)(2\pi r_0)}{60(r_0 - r_i)} \qquad (1)$$

A Newtonian fluid is defined as one in which a velocity gradient bears a linear relationship with the shear;

$$\frac{\text{shear force}}{\text{area}} = \tau = \eta \frac{(dv)}{(dy)}$$

In the MacMichael or Couette-type rotational viscometer used in the present investigation, the velocity gradients existing at the different radial position from the inside to the outside of the cup are approximately uniform so that the mean velocity gradient characteristic of a certain cup rotation rate can be ascertained. By causing the cup to rotate at different rates, different velocity gradients can be maintained. The resultant wall shear on the "bob" gives rise to a torque which brings about a twist on a wire suspending the bob. The extent of this twisting is a measure of the shear force and the latter can be determined by appropriate calibration of the apparatus.

In present experiments, cup rotation rates have been varied up to levels representing velocity gradients of 266, 173, and 79 reciprocal seconds for 45.3, 49.5, and 57.8% liquor, respectively, and a linear relation is found between rotation rates and arbitrary scale readings as shown in Figs. 1 and 2. It thus appears that sulphite spent liquors still behave as Newtonian fluids, at least within the scope of the present study at 23°C. up to nearly 60 w. % concentration of dissolved solids.

Other measurements were made at 25°C. using an Ostwald-type capillary viscometer and values of 4360, 188, and 95.5 cp. were found for the liquors at 57.8, 49.5, and 45.3% solids concentration, respectively.

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These values are shown in Fig. 3 along with those previously obtained (*12*). For these same liquors at 25°C., densities were found to be 1.322, 1.254, and 1.233 g. per ml., respectively.

FLUID FRICTION AND HEAT TRANSFER MEASUREMENTS

The experimental equipment was built as a vertical

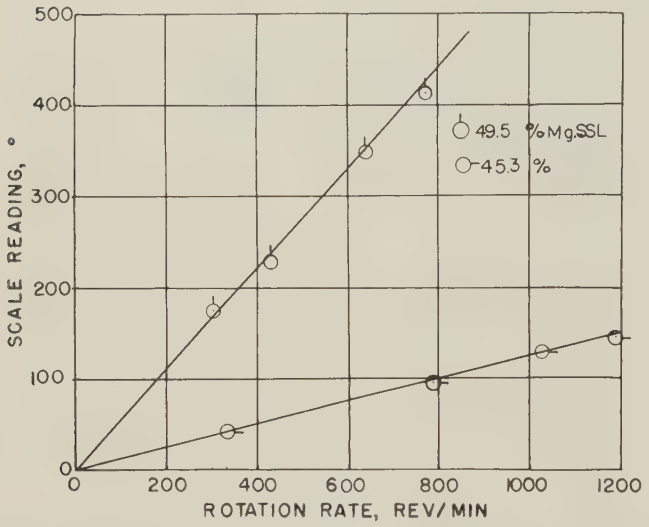

Fig. 1. Scale reading versus revolutions per minute for MacMichael viscometer for 49.5 and 45.3% spent liquor

double pipe heat exchanger and is shown schematically in Fig. 4 and also in the photograph of Fig. 5.

The liquor reservoir was a copper tank divided in two parts, each holding about 25 gal. Fluid from the reservoir was circulated through the system by means of a $1^1/_2$-in. Dayton Dowd open impeller centrifugal pump, which was driven by a 10-hp. Sterling, three-phase motor at 3600 r.p.m. On the suction side of the pump, $1^1/_2$-in. standard galvanized pipe was used. The flow rate was controlled by a $^3/_4$-in. globe valve mounted on the downstream side of the pump. All pipes on the high pressure side were $^3/_4$-in. 304 stainless steel. After passing the valve, the fluid entered the test section. After leaving this part of the apparatus, it was passed through a cooler, built as a cooling jacket around the pipe, and then was returned to the reservoir.

Heat Exchanger

The heat exchange tube had a length of 90.87 in. exposed to steam. The stainless steel pipe was surrounded by a 3-in. standard wrought iron pipe, which was encircled by a 5-in. standard wrought iron pipe. The 3-in. pipe acted as an adiabatic jacket for the exchanger pipe, and eliminated heat losses from the exchanger pipe except for the packing and the flange connections on each end.

Micarta insulating sections were placed at each end of the exchanger pipe, to prevent heat flow out along the pipe. A 2-in. outside diameter Micarta cylinder, $5^1/_2$ in. long, was machined and threads cut in each end, leaving a shoulder in the center. When the pipe was tightened against the shoulder, the inside diameter of the

Nomenclature

A = area of heat transferring surface, sq. ft.
c_p = heat capacity, B.t.u./lb. °F.
D = diameter, ft.
F = friction head, ft. lb. force/lb. mass
f = friction factor, $D\,Fgc/2Lv^2$, dimensionless
g = local acceleration due to gravity, ft./sec.^{2}
g_c = conversion factor = 32.174 lb. mass ft./lb. force sec.^{2} or = $4.17.10^8$ lb. mass ft./lb. force hr.^{2}
h = coefficient of heat transfer (B.t.u./h°F sq. ft.)
Δh = difference in height of the interfaces in the manometer tubes, ft.
k = thermal conductivity, (B.t.u./h sq. ft. °F./ft.)
L = length of pipe, ft.
ΔL = length of pipe between pressure taps, ft.
N_{Nu} = hD/k dimensionless
N_{Pr} = $c_p\mu/k$ dimensionless
N_{Re} = $D\,v\rho/\mu$ dimensionless
N_μ = μ_{bulk}/μ_w dimensionless
p = absolute static pressure lb. force/sq. ft.
Δp = pressure drop, lb./sq. ft.
p_f = pressure drop due to friction, lb./sq. ft.
q = amount of heat transferred through pipe, B.t.u./hr.
r_0 = radius of viscometer cup, cm.
r_i = radius of bob, cm.
r_1 = inside radius of heat exchanger pipe, ft.
r_2 = outside radius of heat exchanger pipe, ft.
t = average liquor temperature, °F.
t_0 = temperature of outer pipe wall, °F.
t_w = temperature at inner pipe wall, °F.
Δt_w = temperature drop through half the pipe wall, °F.
u = internal energy, B.t.u./lb. mass
v = linear velocity, ft./hr. or ft./sec.
W_0 = external work, ft. lb. force/lb. mass
z = height above any arbitrary horizontal datum plane, ft.
Δz = difference in height between pressure taps, ft.
ρ = density of liquor, lb./cu. ft.
ρ_w = density of water, lb./cu. ft.
τ = shear, lb./sq. ft.
η = μ/g_c = viscosity, lb. mass hr./sq. ft.
μ = viscosity, lb./ft. hr.
μ_w = viscosity at inner wall temperature, lb./ft. hr.

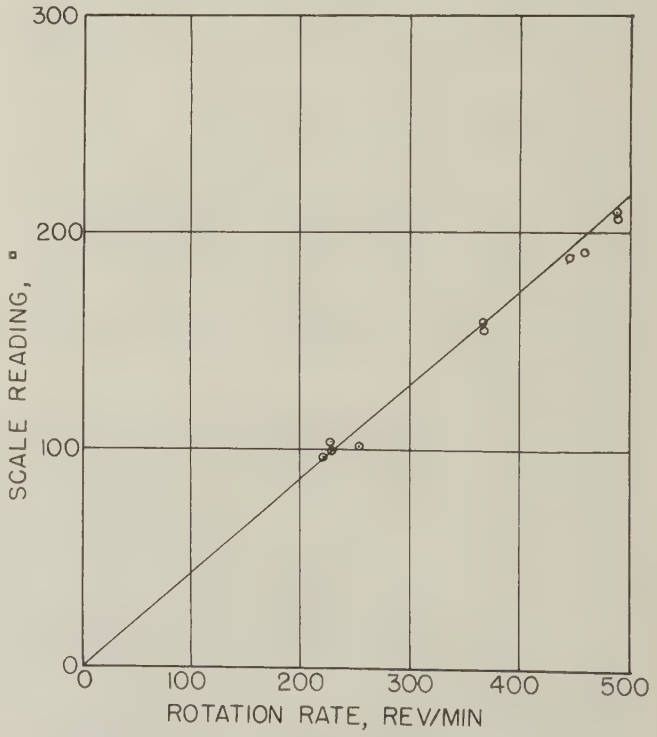

Fig. 2. Scale reading versus revolutions per minute for MacMichael viscometer for 57.8% spent liquor

Micarta cylinder was exactly that of the exchanger pipe. A smooth bore was obtained in this manner.

Garloch $^1/_8$-in. graphite impregnated asbestos pack-

ing served as a steam seal. Steam was supplied at a pressure of 125 p.s.i., and was reduced by means of an automatic reducing valve to approximately 20 p.s.i. before it entered the steam manifold. The steam entered the outer annulus at three different places; at the top,

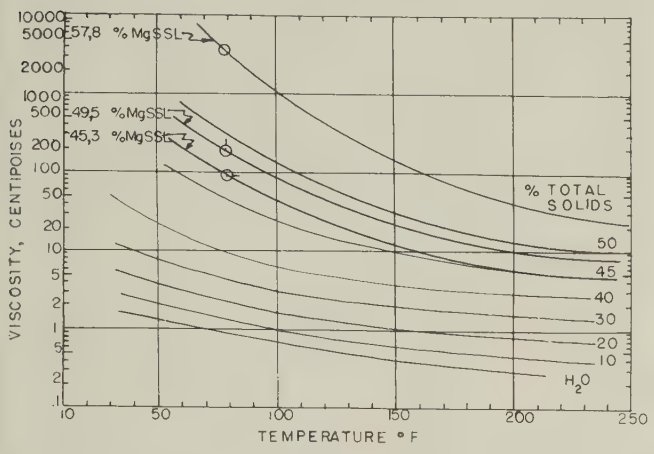

Fig. 3. Viscosity versus temperature and total solids concentration of spent sulphite liquor

at the middle, and in the bottom. Twenty-five $^1/_2$-in. holes were drilled in the 3-in. pipe, which allowed the steam to enter the inner annulus without any appreciable pressure drop. The steam pressure was measured after the pressure reducer by means of an Ashcroft pressure gage. The exchanger was continually vented during the experiments to prevent trapping of noncondensable gases.

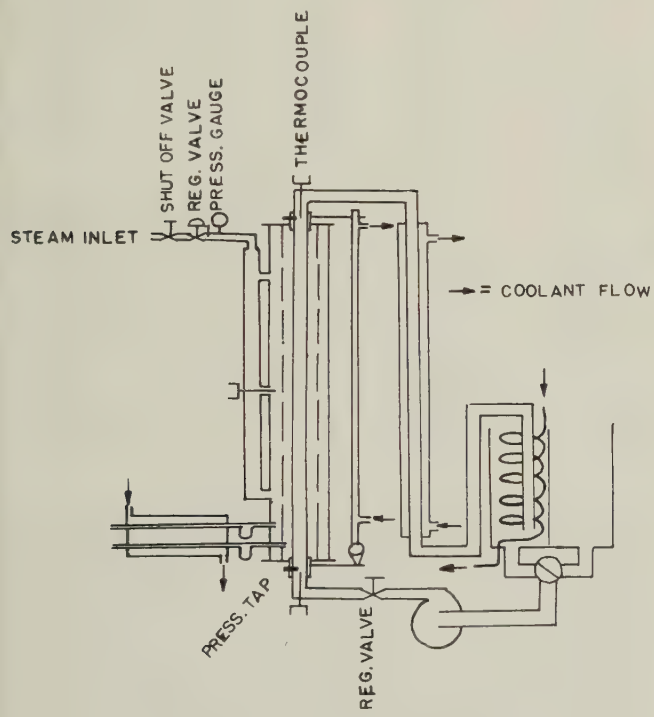

Fig. 4. Schematic drawing of apparatus

The condensate was drained separately from the inner and outer annulus, through steam traps. The amount drained from the inner annulus is a direct measure of the amount of heat being transferred to the liquor during the test period, except for the heat losses through the Micarta cylinder which were assumed to be negligible.

The jacket for the main cooler consisted of an 8-ft. length of a $2^1/_2$-in. diam. galvanized iron pipe connected through reducers to packing glands on the $^3/_4$-in. stainless steel pipe.

To the outside of the copper reservoir was soldered copper tubing about 50 ft. in length. Inside one of the sections of the reservoir was coiled another 50 ft. of copper tubing. Using this cooling arrangement it was possible to retain steady state conditions down to a temperature of 120°F. for the liquor entering the test section.

Pressure and Temperature Measurements

Pressure taps, placed 100.5 in. apart on the test section, were connected by means of copper tubing to a mercury-filled manometer. On top of the manometer were placed cocks to permit removal of any trapped air.

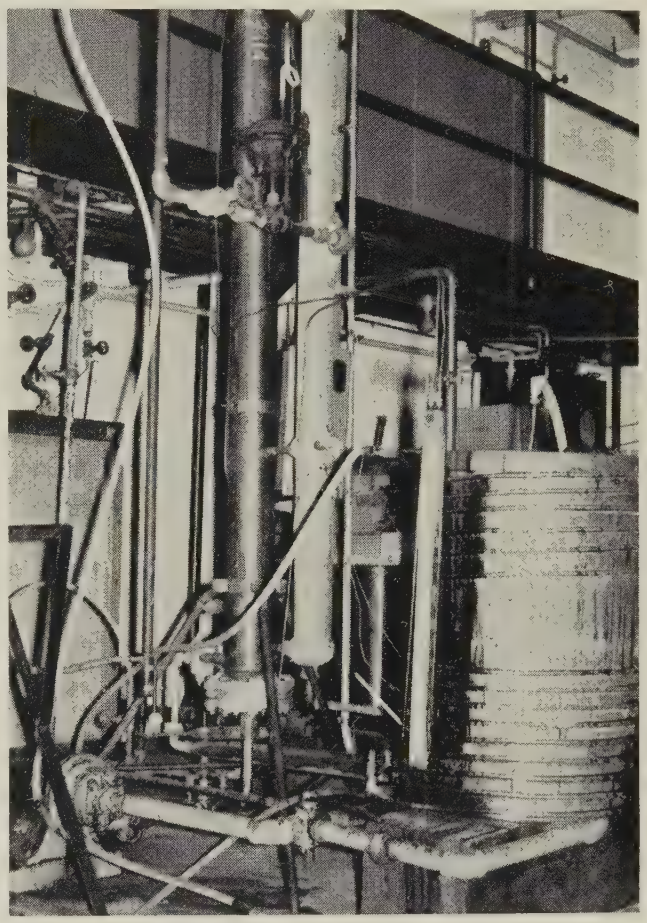

Fig. 5. Photograph of apparatus

The inlet temperature, the outlet temperature, and the steam temperature were measured with copper-constantan thermocouples. These were constructed from 24 B & S gage Leeds & Northrup thermocouple wires soldered into stainless steel thermocouple wells and connected to a potentiometer. The temperature of the liquor in the reservoir was measured to ±0.1°C. using a mercury thermometer.

Measurement of the Temperature of the Heat Exchanger Tube

A problem in some prior studies on heat transfer coefficients has been the correct measurement of the tem-

perature of the surface of the heat exchanger tube. The usual way to get this temperature has been to mount a series of thermocouples on the surface, taking the average of the readings to be the average surface temperature. A different procedure was used in the present investigation.

The elongation of the heat exchanger pipe with change in temperature was measured and the measured elongation was taken to be directly proportional to the mean temperature of the pipe, measured in the middle of the pipe wall, assuming no substantial difference in thermal expansion coefficient over the range considered, i.e., 120 to 270°F. The measurement of the elongation was made in the following manner: On each of the two Micarta insulators, adjacent to the exchanger, was fastened a steel arm at right angles to the pipe. At the outside end of these arms was fastened another pipe aligned in parallel to the vertical exchanger pipe. Cooling water was run through this reference pipe to maintain constant its length. As the heat exchanger pipe was heated and elongated, the reference pipe maintained a constant length, and the elongation of the exchanger pipe was measured using a dial gage arranged as shown in Fig. 6. Calibration for a temperature difference of 189°F. showed that the resulting elongation amounted to 0.148 in. which corresponds to 189/148 = 1.28°F. temperature difference per 0.001 in. elongation.

Procedure for Experimentation

The liquor to be studied was put into one of the two compartments in the reservoir. The steam was turned on and the liquor pumped through the heat exchanger. When the liquor entering the test section reached the desired temperature, the coolers were started up. The valve controlling the flow rate was then set in the desired position, and the flow of cooling water was so regulated that steady state conditions were achieved, i.e., so that the temperature of the liquor entering the heat exchanger was constant during the test period. The liquor was collected in the second chamber in the reservoir, and by measuring the time to fill the chamber, the flow rate could be computed, since the volume of the chamber was known. The flow rate was checked twice during each test; once in the beginning and once at the end. Since the temperature of the liquid and the pressure drop across the test section were held constant, as it was observed that they were, the rate of flow during the test period remained constant and equal to that measured.

The inlet, outlet, and steam temperature and steam pressure were measured as previously described, and the condensate from the inner annulus was collected and weighed for each run. The line leading to the manometer was bled during each test to assure correct

Table I. Observations and Calculation of Friction Factors

Run	t = Inlet liquor temperature,[a] °F.	Steam pressure,[b] p.s.i.	Flow rate, Cu. ft./hr.	Flow rate, Ft./sec.	Elongation, 0.001 in.	Condensate, lb./hr.	Pressure drop, in. Hg	Correction factor	Δp, lb./sq. ft.	f = Friction factor
				Water[c]						
1	143.5	15.5	81.5	6.10	95	104.00	1.25	0.926	82	0.00475
2	146.5	15.5	134.6	10.10	94	116.80	3.20	0.926	210	0.00440
3	139.0	15.5	279.0	20.90	86	146.00	12.40	0.926	814	0.00400
				57.8% Mg SSL						
4	122.0	19.0	123.0	9.21	132	30.00	11.40	0.902	727	0.01350
5	122.5	19.0	97.6	7.30	133	27.50	8.40	0.902	536	0.01595
6	121.0	19.0	57.5	4.31	139	21.00	4.40	0.902	279	0.02400
25	132.8	19.0	152.8	11.40	130	35.00	17.40	0.902	1100	0.01400
26	134.5	9.0	130.0	9.73	126	28.50	10.40	0.902	664	0.01160
27	136.3	11.0	81.2	6.09	130	22.40	6.30	0.902	402	0.01790
28	132.8	13.0	45.6	3.42	133	20.80	3.00	0.902	191	0.02700
29	151.0	20.0	192.4	14.42	139	31.05	18.10	0.902	1155	0.09200
30	151.0	20.0	145.2	10 86	142	28.00	12.30	0.902	777	0.01060
31	154.5	18.0	87.6	6.56	143	28.00	5.40	0.902	344	0.01330
				49.52% Mg SSL						
7	112.1	7.0	216.0	16.47	108	70.20	23.00	0.906	1470	0.00925
8	119.2	17.5	173.0	12.93	124	59.04	13.80	0.906	884	0.00906
9	119.2	18.0	110.1	8.24	125	46.00	5.10	0.906	327	0.00830
10	158.0	16.0	235.0	17.61	130	64.52	22.50	0.906	1440	0.00800
11	160.5	17.0	172.5	12.90	136	58.24	11.90	0.906	763	0.00790
12	158.5	17.0	102.4	7.66	140	36.88	5.30	0.906	339	0.01000
13	193.5	17.0	244.5	18.30	144	53.04	20.70	0.906	1330	0.00690
14	192.0	17.0	165.7	12.40	143	43.60	10.00	0.906	640	0.00724
15	191.0	17.0	99.2	7.43	142	30.60	5.60	0.906	358	0.01130
				45.34% Mg SSL						
16	116.5	18.0	229.5	17.20	107	86.40	22.30	0.909	1435	0.00848
17	121.0	17.0	197.0	14.75	116	84.48	13.90	0.909	843	0.00720
18	119.2	17.0	157.6	11.80	120	74.04	8.10	0.909	520	0.00660
19	118.0	17.0	83.6	6.26	132	47.00	2.80	0.909	180	0.00810
20	148.6	17.0	247.5	18.58	126	76.40	22.70	0.909	1455	0.00745
21	153.0	19.0	217.0	16.22	132	74.80	13.70	0.909	878	0.00608
22	149.0	16.0	146.1	10.92	133	65.00	8.10	0.909	520	0.00773
23	155.0	17.0	85.6	6.41	139	44.60	2.70	0.909	174	0.00752
24	184 0	17.0	255.4	19.15	143	60.40	21.60	0.909	1390	0.00678

[a] Outlet liquor temperature was also observed but the difference between outlet and inlet temperature was so small that inlet temperature could be taken as average temperature.
[b] Steam temperature was observed and found in all experiments to correspond to approximately 1°F. superheated steam.
[c] t is here actual average temperature.

measurement. The apparatus was flushed with water each time the liquor was changed, and no scale formation was observed. The observations and calculated results are assembled in Tables I, II, and III.

FRICTION FACTOR CALCULATIONS AND RESULTS

The Bernoulli equation

$$\frac{d(gz)}{g_c} + \frac{udu}{g_c} + \frac{dp}{\rho} = -\delta W_0 - \delta F \qquad (2)$$

is the basic relationship used for computation of the Fanning friction factors. Definitions of symbols used are given below in a tabulation. Integration of this equation, using the restrictions of steady state flow, constant gravity acceleration and density, no shaft work, and neglecting kinetic energy effects, gives:

$$\frac{g(\Delta z)}{g_c} + \frac{\Delta p}{\rho} = -F = \frac{\Delta p_f}{\rho} \qquad (3)$$

Measurements of Δp were made by use of a water-mercury manometer and Δh represented the difference in heights of the interfaces in the manometer tubes. Applying equation (2) to the manometer system gives:

$$\Delta p_f = -\frac{\rho_w g}{g_c}[\Delta z + \Delta h'(13.6 - 1)] \qquad (4)$$

which, by combination with equation (3), yields

$$\Delta p_f = \rho F = \rho\left(\frac{g}{g_c}\right)\Delta z - \rho_w\left(\frac{g}{g_c}\right)(\Delta z) - 12.6\rho_w\left(\frac{g}{g_c}\right)(\Delta h) \qquad (5)$$

and by rearrangement and using Δh instead of $\Delta h'$

$$\Delta p_f = (\rho - \rho_w)\left(\frac{g}{g_c}\right)(\Delta z) - 0.926\rho_w\left(\frac{g}{g_c}\right)(\Delta h) \qquad (6)$$

The values of this pressure drop arising from friction have been calculated and the results are shown in Table I. Also given are the "correction factors" which are the values of the terms involving Δz in equation (6) as computed using appropriate spent sulphite liquor densities as previously estimated (*12*).

Table II. Calculation of Heat Transfer Coefficients

Run	Heat transferred, B.t.u./hr.	Heat transferred through 1 ft. of pipe, B.t.u./hr. ft.	Δt_w = Temperature drop through half the pipe °F.	Temperature in the middle of the pipe wall, °F.	t_w = Temperature at inside pipe wall, °F.	Temperature difference between wall and fluid, °F.	h = Heat transfer coefficient, B.t.u./hr. °F. sq. ft.
			Water				
1	98,300	12,800	18.8	196.8	178.0	34.5	1715.0
2	110,200	14,600	21.5	195.0	173.5	27.0	2510.0
3	138,100	18,250	26.9	185.0	158.1	19.1	4450 0
			57.8% Mg SSL				
4	27,350	3,620	5.3	244.0	238.7	116.7	143.0
5	24,900	3,300	4.8	245.0	240.2	117.7	129.0
6	19,030	2,520	3.7	253.0	249.3	128.3	91.0
25	32,950	4,360	6.4	256.0	249.6	116.8	173.0
26	26,950	3,565	5.2	236.0	230.8	96.3	171.0
27	21,400	2,830	4.2	241.0	236.8	100.5	130.0
28	19,700	2,610	3.8	245.0	241.2	108.4	111.5
29	29,200	3,870	5.7	253.0	247.3	96.3	186.0
30	26,350	3,490	5.1	257.0	251.9	100 9	160.0
31	20,000	2,650	3.9	258.0	254.1	99.6	122.0
			49.52% Mg SSL				
7	67,400	8,930	13.1	213.0	199.9	87.8	471.0
8	56,400	7,460	11.0	233.0	222.0	102.8	337.0
9	41,300	5,460	8.1	235.0	226.9	107.7	235.0
10	61,000	8,070	11.9	241.0	229.1	71.1	524.0
11	54,900	7,270	10.7	249.0	238.3	77.8	432.0
12	34,750	4,600	6.8	254.5	247.7	89.2	238.0
13	50,000	6,620	9.7	259.0	249.3	56.8	540.0
14	41,000	5,430	8.0	258.0	250 0	58.0	433.0
15	28,850	3,820	5.6	257.0	251.4	60.4	293 0
			45.34% Mg SSL				
16	81,150	10,800	16.3	212.0	195.7	79.2	630.0
17	79,700	10,560	15.5	224.0	208.5	87.5	557.0
18	70,000	9,260	13.6	232.0	218.4	99.2	432.0
19	44,300	5,870	8.6	244.0	235.4	117.4	231.0
20	72,100	9,550	14.0	236.0	222.0	73.4	603.0
21	70,500	9,340	13.7	244.0	230.3	77.3	559.0
22	61,500	8,140	12.0	245.0	233.0	84.0	448.0
23	42,100	5,570	8.2	253.0	244.8	89.8	288.0
24	57,000	7 550	10.2	258.0	247 8	63.8	549.0

The Fanning equation,

$$\Delta p_f = \frac{4f(\Delta L)v^2}{2Dg_c} \qquad (7)$$

permits the correlation of frictional pressure drops with fluid and system characteristics in terms of the dimensionless Fanning friction factor

$$f = \frac{(\Delta p_f)Dg_c}{2(\Delta L)gv^2} \qquad (8)$$

which, in the present case, was readily calculated and the results are given in Table I.

The experimental equipment was first operated using

water. From appropriate measurements, friction factors, and Reynolds, Prandtl, and Nusselt numbers were calculated.

The experimental results for water and the spent liquors were considered relative to the usual relationship between friction factor and Reynolds number for smooth pipes. When the Reynolds number was computed using the viscosity and other properties at the bulk temperature of the fluid, moderately good agreement was found in the turbulent range but not below Reynolds number values of about 800. However, if the Reynolds number was computed using the viscosity and other properties were calculated at the "film" temperature (i.e., the arithmetic mean of the wall temperature and the fluid bulk temperature), then moderately good agreement was found between the experimental and predicted friction factors over the whole range of Reynolds numbers studied as indicated in Fig. 7.

The temperature measured by means of the elongation thermometer is approximately the distance average temperature of the pipe over its length and through its thickness. From the known heat flow rate through the pipe wall and with the conduction equation

$$q = \frac{2\pi k(t_0 - t_w)L}{\ln r_2/r_1} \qquad (10)$$

there was calculated the temperature drop occurring between the center and the inside surface of the pipe wall

$$\Delta t_w = \frac{q \ln (r_2/r_1)}{4\pi kL} = \frac{q}{680} \qquad (11)$$

and this value was used to modify the "elongation" temperature to obtain the temperature at the inside pipe wall. The inlet liquor temperature was measured and was taken to be the mean liquor temperature (except in the experiments with water) in view of the relatively small temperature increase experienced in the heater.

From the wall-fluid temperature difference and the heat transfer area per unit length (1.632 sq. ft per ft.), the heat transfer coefficients were computed by equation (9) and are given in Table II.

The heat transfer coefficients obtained experimentally with water and with the spent liquors have been compiled and can be considered conveniently in terms of the values and the dimensionless Nusselt numbers shown

Table III. Calculation of Reynolds, Prandtl, and Nusselt Numbers[a]

Run	Viscosity at t, lb./ft. hr.	Viscosity at t_w, lb./ft. hr.	Thermal conductivity B.t.u./hr. sq. ft. °F./ft.	Density, lb./cu. ft.	Exp. results N_{Re}	Exp. results N_{Pr}	Exp. results N_{Nu}	Pred. by S & T N_{Nu}	N_{Nu} Pred. needs N_{Nu} exp.
				Water					
1	1.11	0.85	0.376	61	83,000	2.95	330	346	1.05
2	1.09	0.88	0.377	61	140,000	2.89	486	504	1.031
3	1.14	1.05	0.374	61	280,000	3.05	851	910	1.072
				57.8% Mg SSL					
4	966	58.0	0.315	80	189	2270	31.2	43.3	1.39
5	960	57.0	0.316	80	151	2250	28.0	40.0	1.43
6	970	52.1	0.314	80	88	2290	19.9	34.2	1.72
25	652	52.0	0.319	80	347	1514	37.3	44.5	1.19
26	610	65.2	0.320	80	316	1412	36.7	40.5	1.11
27	580	60.5	0.321	80	208	1340	27.9	34.7	1.24
28	652	56.5	0.319	80	104	1515	24.1	29.5	1.23
29	339	53.2	0.323	80	840	779	39.6	43.8	1.11
30	339	50.7	0.323	79	625	779	34.0	39.8	1.17
31	315	50.0	0.325	79	413	721	25.8	33.4	1.29
				49.5% Mg SSL					
7	126	24.2	0.320	77	2,510	303	101	119	1.18
8	116	21.8	0.322	77	2,130	277	72	102	1.42
9	116	19.6	0.322	77	1,350	277	50.2	35.5	0.71
10	46	19.3	0.334	76	7,230	109	108	178	1.65
11	43.5	18.6	0.335	76	5,520	103	88.6	142	2.00
12	46	18.2	0.334	76	3,140	109	49	91.2	1.87
13	26.6	18.2	0.343	76	12,850	59.7	107	212	1.98
14	29.1	18.2	0.342	76	7,950	65.5	87	153	1.76
15	31.0	18.2	0.341	76	4,500	70.0	59	98	1.66
				45.3% Mg SSL					
16	67.6	13.6	0.325	76	4,760	164	133	161	1.21
17	63.0	13.0	0.327	75	4,370	152	118	146	1.24
18	65.0	12.8	0.326	75	3,380	158	91	120	1.32
19	66.0	12.1	0.326	75	1,755	160	48.5	32.4	0.67
20	29.0	12.1	0.334	75	11,800	68.5	124	225	1.82
21	27.0	12.1	0.336	75	11,200	63.5	115	210	1.82
22	28.0	12.1	0.335	75	7,200	66.0	92	145	1.58
23	25.4	12.1	0.337	74	4,630	59.5	59	100	1.69
24	16.5	12.1	0.344	74	21,200	37.9	110	271	2.46

[a] Specific heats were taken to be 0.74, 0.77, and 0.79 B.t.u./lb. °F. for 57, 49.52, and 45.34% solids respectively.

HEAT TRANSFER CALCULATIONS AND RESULTS

A liquor-side heat transfer coefficient is defined by the Newton heat transfer equation:

$$q = h \cdot A(t_w - t) \qquad (9)$$

The heat transfer rate was computed by multiplying the weight of condensate obtained per unit time by its enthalpy of vaporization and dividing by the length of the heat transfer section.

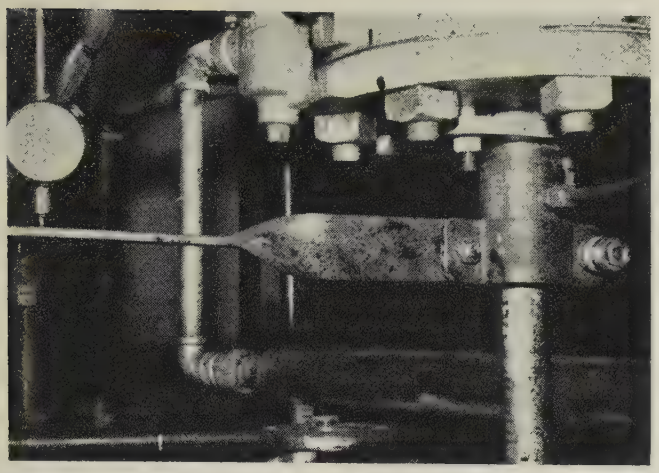

Fig. 6. Photograph of equipment to measure the elongation

in Tables II and III. Predicted values of the Nusselt numbers were computed from experimental values of Reynolds and Prandtl numbers by use of the equations of Sieder and Tate (*13*) for streamline flow

$$N_{Nu} = 1.86[(N_{Re})(N_{Pr})(D/L)]^{1/3}(N_{\mu})^{0.14} \qquad (12)$$

and turbulent flow

$$N_{Nu} = 0.027 N_{\mu}^{0.14} N_{Pr}^{1/3} N_{Re}^{0.8} \qquad (13)$$

which were obtained by dimensionless analysis with numerical values established by experiment and also by use of the boundary layer theory equations of Prandtl (*14*)

$$N_{Nu} = \frac{0.04 N_{Re}^{0.75} N_{Pr}}{1 + 1.74 N_{Re}^{-1/8}(N_{Pr} - 1)} \qquad (14)$$

and of von Kármán

$$N_{Nu} = \frac{0.04 N_{Re}^{0.75} N_{Pr}}{1 + N_{Re}^{-1/8}\{N_{Pr} - 1 + Ln/[1 + 5/6(N_{Pr} - 1)]\}} \qquad (15)$$

When the Reynolds and Prandtl numbers were computed using the viscosity and other properties at the film temperature, departures were evident between the predicted and the experimental values of Nusselt numbers over certain ranges of Prandtl numbers, i.e., over the range of Prandtl number 50 to 100 for the Prandtl equation, and above Prandtl number 100 for the von Kármán equation. Similar difficulties with these equations are evident using properties calculated at the bulk temperatures perhaps in part because of the existence of substantial temperature and viscosity gradients across the film.

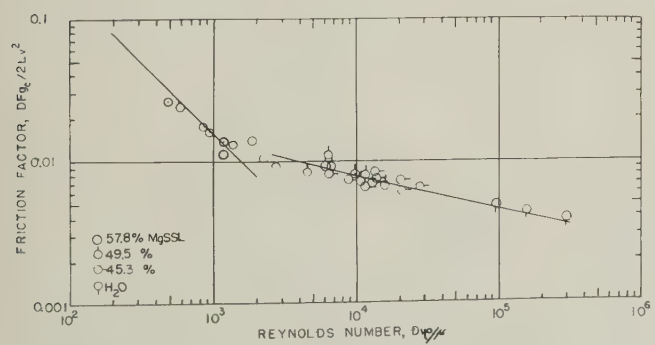

Fig. 7. Friction factor versus Reynold's number for spent sulphite liquors

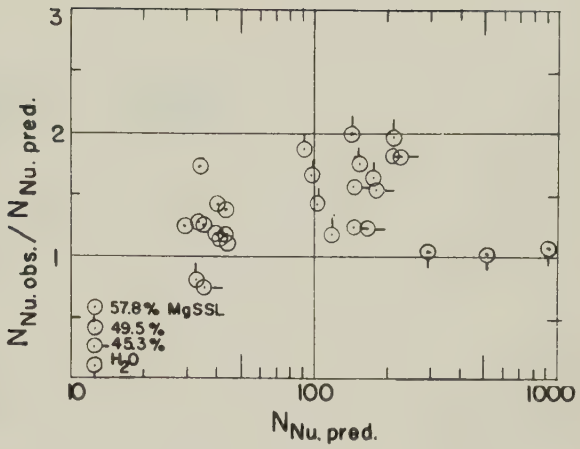

Fig. 8. Ratio of Nusselt numbers observed to those predicted by the Sieder and Tate equation versus predicted Nusselt numbers

The numerical parameters in the Sieder and Tate equation were derived empirically using viscosity and other properties calculated at the bulk temperature of the fluid so the Nusselt numbers predicted on this basis were compared with those found experimentally. The values for the Reynolds numbers fall in both the turbulent and the streamline range and most of the predicted Nusselt numbers are somewhat higher than those found experimentally as is shown in Fig. 8. The differences between observed and predicted values of the heat transfer coefficient probably arise because the viscosity data used in the prediction calculations was obtained by interpolation from the previously smoothed data. It is believed that better agreement between observed values and those predicted by the Sieder and Tate equation would have been obtained by using the specific viscosity characteristics of the particular liquors studied.

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Spent Sulphite Liquor IX

Solubility Relationships in the System Na_2CO_3–Na_2S–H_2O (35–95°C.)

R. MARTIN, VINCENT F. FELICETTA, and JOSEPH L. McCARTHY

The compositions of liquid solution and solid phases at equilibrium at 35, 60, and 95°C. in the system Na_2CO_3–Na_2S–H_2O have been determined by experiments and isothermal invariant points have been located approximately at 35 and 60°C. The results indicate that sodium carbonate can be separated in moderately good yield by crystallization from an aqueous solution containing both sodium carbonate and sodium sulphide.

MANY schemes have been proposed for treating the spent liquors from sulphite cellulose pulp manufacture to accomplish recovery therefrom of process chemicals for re-use, and of heat as useful steam from combustion of organic substances present. One such process under investigation in this laboratory (*3*) involves the treating of sodium-base sulphite spent liquor and includes the following series of steps: (1) steam stripping, possibly neutralization, and then concentrating the spent liquor by evaporation, (2) burning of the concentrated liquor solids in a Tomlinson-type furnace, (3) collecting the furnace smelt or molten salt solution, separating sodium carbonate therefrom by selective dissolving of the smelt into aqueous solution or by crystallizing from aqueous solution, and recycling the remaining sodium sulphide solution into the furnace, and (4) redissolving the sodium carbonate and use of the resultant solution for absorption of sulphur dioxide from the furnace stack gas to provide a sodium bisulphite solution for re-use, and for other purposes.

One questionable feature of this process is the step of selective dissolving or crystallizing the furnace smelt to provide substantially pure sodium carbonate in crystalline form and in high yield relative to that remaining in aqueous solution along with sodium sulphide. The feasibility of this separation depends in part on the status of the thermodynamic phase equilibria in the system in which sodium carbonate, sodium sulphide, and water are the major components although small amounts of sodium sulphate may also be present.

The solubility in water of sodium carbonate (*1, 5, 9, 10*), sodium sulphide (*1, 7, 8, 9*), and sodium sulphate (*1, 9*) at various temperatures has been reported and the results are summarized in Fig. 1. Some numerical values for solubility along with specifications of stable crystalline phases for carbonate and sulphide are given in Table I. The ternary system Na_2SO_4–Na_2S–H_2O has been studied (*4*). No information could be found for the ternary system Na_2CO_3–Na_2S–H_2O so therefore the present investigation was carried out to obtain solubility and phase equilibrium data for this system over a limited range of temperature.

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MEASUREMENTS OF LIMITING SOLUBILITY

Most experiments were conducted using reagent grade anhydrous sodium carbonate (Merck and Co., Inc.) containing not more than 0.001% S as sulphate, and reagent grade sodium sulphide nonyl hydrate (J. T. Baker Chemical Co.) containing less than 0.02% sodium thiosulphate and other impurities. In certain cases a "purified" sodium sulphide nonyl hydrate (J. T. Baker Chemical Co.) containing about 1 w. % sodium sulphate was used.

Solubility measurements at several temperatures were conducted using the apparatus shown in Fig. 2 including a Cartesian diver-type manostat, N, to control the pressure to provide the required temperatures. The desired amounts of anhydrous sodium carbonate and sodium sulphide nonahydrate were weighed to the nearest hundredth gram into the equilibration flask, C, and water was added by volume to make a total of 300 g. H_2O present. The flask and contents were placed in an oil bath, A, and the mixture was boiled under reflux at the desired temperature provided by the controlled pressure until all salts had dissolved and a clear solution remained.

Then cooling water was drained from the reflux con-

Table I. Phase Equilibrium in the Systems Na_2CO_3–H_2O and Na_2S–H_2O

Temperature, °C.	*Solution phase, g. anhydr. salt/ 100 g. H_2O*	*Solid phase*
	The System Sodium Carbonate–Water (*5*)	
20	22.2	$Na_2CO_3 \cdot 10H_2O$
25	29.4	$Na_2CO_3 \cdot 10H_2O$
30	39.2	$Na_2CO_3 \cdot 10H_2O$
32.00	45.4	$Na_2CO_3 \cdot 10H_2O + Na_2CO_3 \cdot 7H_2O$
35.37	49.5	$Na_2CO_3 \cdot 7H_2O + Na_2CO_3 \cdot 1H_2O$
40	48.8	$Na_2CO_3 \cdot 1H_2O$
60	46.3	$Na_2CO_3 \cdot 1H_2O$
95	44.8	$Na_2CO_3 \cdot 1H_2O$
109	44.5	$Na_2CO_3 \cdot 1H_2O + Na_2CO_3$
110	44.5	Na_2CO_3
	The System Sodium Sulfide -Water (*7*)	
20[a]	18 7[a]	$Na_2S \cdot 9H_2O$
25[a]	20.4[a]	$Na_2S \cdot 9H_2O$
30[a]	22.6[a]	$Na_2S \cdot 9H_2O$
35[a]	25.3[a]	$Na_2S \cdot 9H_2O$
40[a]	28.1[a]	$Na_2S \cdot 9H_2O$
48.9	...	$Na_2S \cdot 9H_2O + Na_2S \cdot 5^1/_2H_2O$
50	39.8[b](36.4)[b]	$Na_2S \cdot 5^1/_2H_2O$
60	42.7 (39.1)	$Na_2S \cdot 5^1/_2H_2O$
70	45.7 (43.3)	$Na_2S \cdot 5^1/_2H_2O$
80	51.4 (49.1)	$Na_2S \cdot 5^1/_2H_2O$
90	59.2 (57.3)	$Na_2S \cdot 5^1/_2H_2O$
91.5[c]	...	$Na_2S \cdot 5^1/_2H_2O + Na_2S \cdot H_2O$

[a] Interpolated from a graph made using the published data (*1, 7*).
[b] The numbers given in the parentheses are the solubilities reported (*7*) in relation to a hexahydrate solid phase.
[c] The transition $Na_2S \cdot 5^1/_2H_2O + Na_2S \cdot H_2O$ has been reported to occur at 86°C (*8, 9*).

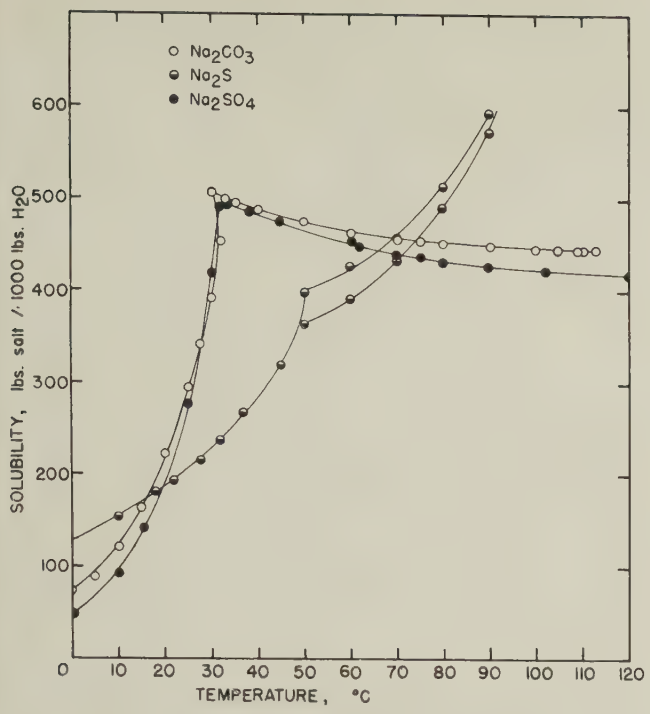

Fig. 1. Water solubility of sodium carbonate, sodium sulphide, and sodium sulphate

denser, E, and water vapor was removed by evaporation and condensed in condenser, E_2, in condensate trap, H, in ice bath I, and finally in cold finger condenser, J, situated in a dry ice-acetone bath, K. The oil bath temperature was 20 to 35°C. higher than the solution temperature so the solution boiled vigorously during evaporation. However, at 35°C. the solution was quite viscous so nitrogen was bubbled through the solution to prevent bumping and to speed evaporation. Removal of water was continued until the solution had reached the desired composition in the two-phase region as estimated roughly by observation of the volume of water condensed. Water was passed through the reflux condenser again and the solution was refluxed for 45 to 60 min. to permit phase equilibrium to be attained. During this period, temperature fluctuations were less than 1°C. At the higher temperatures, the solutions turned yellow in color and the color intensity increased with increase in concentration of sodium sulphide in solution.

The suspension was very rapidly filtered with vacuum through a coarse 350-ml. fritted glass funnel and a 10-ml. sample of clear filtrate was immediately taken using a pipet. Before use the pipet, funnel, and filter flask were preheated to a temperature slightly above the solution temperature. Solution was drained from crystals which in some cases were rinsed with ethanol. Finally the crystals were blotted between filter papers to remove as much liquid as possible.

ANALYTICAL METHODS

The saturated solution samples (10 ml.) and the crystals obtained were weighed and diluted or dissolved with water to 250 and 500 ml., respectively, and sodium carbonate and sodium sulphide were determined in aliquots. In some cases sodium sulphate was also determined.

Total Alkali. A 5-ml. aliquot was pipetted into a 250-ml. Erlenmeyer flask, a known excess 0.1 *N* H_2SO_4 or HCl was added, CO_2 and H_2S were volatilized, and the remaining acid was determined by back titration with 0.1 *N* NaOH using a phenolphthalein indicator. The difference between equivalents of acid added and that remaining is the equivalent of total alkali.

Sodium Sulphide. For analysis of saturated solutions, a known excess of standard 0.1 *N* iodine solution was pipetted into a 250-ml. Erlenmeyer flask. Sufficient 2:5 glacial acetic acid-water mixture to make the final mixture acidic was added and then a 5-ml. aliquot was introduced. Unreacted iodine was back titrated with 0.1 *N* sodium thiosulphate solution using a starch indicator, and the difference between the equivalents of iodine added and those remaining represents the sodium sulphide. For analysis of crystals a 50-ml. aliquot was titrated with ammoniacal 0.513 *N* $AgNO_3$ solution to an end point at which no further precipitation occurred, and each milliliter of silver nitrate solution was equivalent to 0.02 g. Na_2S.

Sodium Carbonate. The difference between the equivalents found for total alkali and for sodium sulphide was taken to be sodium carbonate.

Sodium Sulphate. A 10-ml. aliquot was passed through a Dowex 50 HCR resin column to remove sodium, the resultant acid mixture was boiled for 10 to 20 min. to remove carbon dioxide and hydrogen sulphide, and then the remaining sulphuric acid was determined by titrating with 0.1 *N* NaOH to the phenolphthalein end point.

EXAMPLE CALCULATION

For experiment 10 at 60°C., water (188 g.), anhydrous sodium carbonate (39 g.), and sodium sulphide nonahydrate (54 g. Na_2S; 112 g. H_2O) were used to provide an initial mixture weighing 393 g. and 9.9, 13.7, and 76.4 wt. %. Na_2CO_3, Na_2S, and H_2O, respectively. The water distillate weighed 115 g. so the final system mixture weighed 278 g. and was 14.1, 19.4, and 66.5 wt. % Na_2CO_3, Na_2S, and H_2O, respectively.

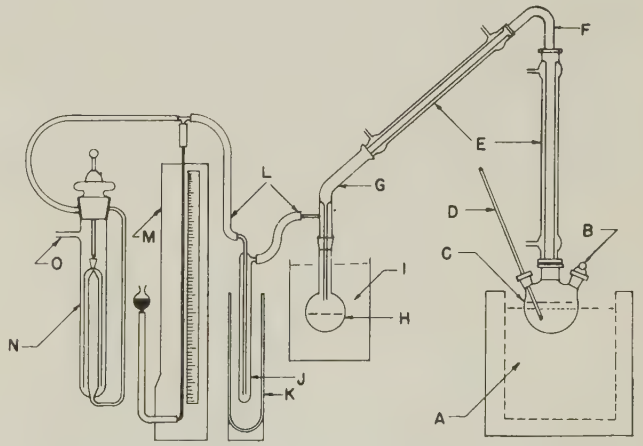

Fig. 2. Apparatus used for phase equilibrium studies

A—Constant temperature oil bath with continuous stirring. B—Extra joint plugged with a ground glass stopper. C—500-ml. three-necked flask with ground glass joints. D—Thermometer. E—Condensers with cooled ground glass joint. F—Connecting tube with 55° bend. G—Special adapter. H—Condensate trap, 200 ml. capacity. I—Ice bath. J—Cold finger type condenser. K—Dewar containing dry ice and acetone mixture. L—Pressure tubing. M—Manometer. N—Cartesian diver-type manostat, Scientific Supplies Co. catalog no. 31718. O—To vacuum source.

Table II. Compositions of Solutions and Solids at Equilibrium in the System Na_2CO_3-Na_2S-H_2O

Expt. no.	Temp., °C.	Approx. pressure, mm. Hg	Solution, wt. % Na_2CO_3	Solution, wt. % Na_2S	Solids, wt. % Na_2CO_3	Solids, wt. % Na_2S
1	37	19	3.4	20.6	1.0	31.5
2	35	28	5.3	20.0	4.2	29.4
3	35	30	6.8	18.2	28.2	20.0
4	35	29	8.5	16.6	...	(Trace)
5	35	29	12.8	13.1	82.2	(Trace)
6	35	29	19.8	8.0	88.5	0.1
7	60	100	1.0	29.4	17.2	34.1
8	60	100	1.0	29.9	18.5	34.8
9	60	110	1.4	29.0[a]	85.0	0.2
10	60	94	3.7	21.8[a]	80.5	1.4
11	60	109	4.3	21.0[a]	79.5	1.8
12	60	100	7.1	17.0[a]	80.2	1.1
13	60	109	10.7	13.7[a]	80.6	0.3
14	60	111	11.2	13.3	84.0	0.5
15	60	107	12.8	11.9	66.5	0.5
16	60	108	17.6	8.6	81.5	(Trace)
17	60	120	24.5	4.0	83.8	~0
18	94	348	2.3	26.0	75.1	4.7
19	94	345	3.0	24.0	84.5	3.3
20	94	384	4.3	20.4	94.8	0.6
21	95	468	7.7	17.0	78.5	0.6
22	94	456	11.5	12.7	74.3	0.1
23	95	502	17.5	8.1	82.3	~0
24	108	740	...	55.0	...	...
25	109	621	1.7	29.0	59.2	12.2
26	109	668	4.1	21.6	90.1	1.4
27	109	662	6.5	19.6	97.3	0.7
28	109	740	7.2	16.5	93.8	0.2
29	107	740	14.2	10.3	86.9	0.3
30	107	740	19.8	6.8	...	...

[a] Analyses of these solutions showed that Na_2SO_4 present was less than 0.1% by weight.

The 10-ml. sample of saturated solution weighed 12.34 g. and was made up with distilled water to 250 ml. For total alkali determination, a 5-ml. aliquot of the diluted solution with 25.00 ml. of 0.1166 *N* HCl required 15.61 or 15.64 ml. of 0.0878 *N* NaOH for back titration, thus indicating the presence of 0.00155 equivalents total alkali in the aliquot sample. For sodium sulphide determination, to 25.00 ml. of 0.0977 *N* iodine solution there was added 3 ml. of 2:5 acetic acid-H_2O and a 5-ml. aliquot of the diluted solution sample and 10.70 or 10.71 ml. of 0.0994 *N* sodium thiosulphate was required for back titration, thus indicating the presence of 0.00138 equivalents Na_2S, and, by difference, the presence of 0.00017 equivalents of Na_2CO_3. Thus in the saturated solution sample, 0.45, 2.69, and 9.20 g. of Na_2CO_3, Na_2S, and H_2O were found present, equivalent to 3.7, 21.8, and 74.5 wt. % composition.

The crystals weighed 35.71 g. and were dissolved and made up with distilled water to 500 ml. For total alkali

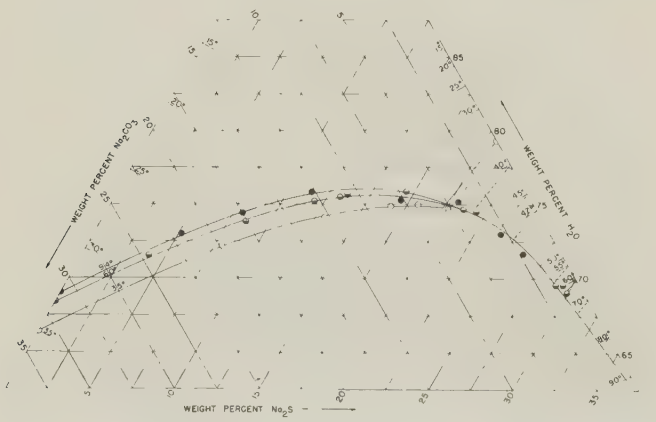

Fig. 3. Triangular diagram of solubility in the system Na_2CO_3-Na_2S-H_2O from 35 to 95°C.

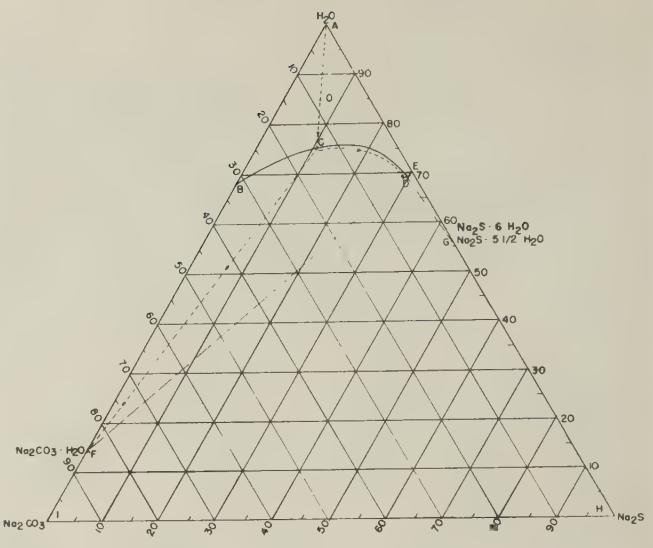

Fig. 1. Triangular diagram indicating separation of crystalline sodium carbonate at 60°C.

determination, a 5-ml. aliquot with 50.00 ml. of 0.1166 *N* HCl required 3.47 or 3.48 ml. of 0.0878 *N* NaOH for back titration, thus indicating the presence of 0.554 equivalents in the 500-ml. sample. For sodium sulphide determination using the silver nitrate precipitation method, a 50-ml. aliquot required 2.6 ml. of 0.513 *N* ammoniacal $AgNO_3$, indicating the presence of 0.0133 equivalents or 0.52 g. of Na_2S in the 500-ml. sample. Equivalents of sodium carbonate by difference amounted to 0.541 or 28.7 g., and therefore 6.5 g. H_2O were present in the crystals. The composition of these crystals is estimated to be 80.5% Na_2CO_3, 1.4% Na_2S, and 18.1% H_2O, as reported in Table II. Assuming the 1.4% Na_2S arises as a result of contamination with adhering solution, then 2.39 g. of saturated solution containing 0.088 g. Na_2CO_3, 0.52 g. Na_2S, and 1.78 g. H_2O are present and a corrected crystal composition is calculated to be 85.9% Na_2CO_3 and 14.1% H_2O which can be compared with the composition of crystalline sodium carbonate monohydrate which is 85.5% Na_2CO_3 and 14.5% H_2O as shown in Table IV.

RESULTS

The solubilities in water of sodium carbonate and of sodium sulphide shown in Table I and Fig. 1 serve to establish boundaries for the results of the presently reported experiments. The solubility of sodium carbonate in water increases rapidly with increasing temperature up to 32.0°C. where transition occurs from the decahydrate to the heptahydrate and then, at 35.37°C. to the monohydrate. Above this temperature and over the

Table III. Compositions of Certain Solutions and Solids at Equilibrium in the System Na_2CO_3-Na_2S-Na_2SO_4-H_2O

Expt. no.	Temp., °C.	Approx. pressure, mm. Hg	Solution, wt. % Na_2CO_3	Solution, wt. % Na_2S	Solution, wt. % Na_2SO_4	Solids, wt. % Na_2CO_3	Solids, wt. % Na_2S	Solids, wt. % Na_2SO_4
31	94	332	3.2	25.0	1.0	64.6	8.9	1.5
32	96	438	3.9	20.2	0.8	84.9	0	0
33	95	393	6.0	18.2	0.6	68.9	0.8	0.2
34	92	358	6.2	19.4	1.2	78.4	1.2	0.8
35	95	443	9.1	15.5	0.4	81.4	0.1	0.5
36	94	446	21.7	5.2	0.3	80.5	0.3	0.3

Table IV. Material Dispositions for Separation[a] of Crystalline Sodium Carbonate at 60°C.

Stream	Point	Composition, wt. %[b] Na_2CO_3	Na_2S	H_2O	Materials in streams[c] Na_2CO_3	Na_2S	H_2O	Total
Initial soln.	O	8.6	6.4	85.0	8.6	6.4	85.0	100.0
Sat. soln.	C	14.0	11.0	75.0	8.6	6.4	43.5	58.5
Final soln.	D	1.5	29.0	69.5	0.3	6.4	15.3	22.0
Na_2CO_3-H_2O	F	85.5	0.0	14.5	8.3	0.0	1.4	9.7
Water	A	0.0	0.0	100.0	0.0	0.0	68.3	68.3

[a] See text for conditions of separation.
[b] Compositions were estimated from Fig. 3.
[c] Basis for calculations is 100 lb. of initial solution or 6.4 lb. Na_2S.

range of present experiments, the solubility decreases slightly up to 109°C. where transition occurs to the anhydrous salt. With sodium sulphide also the solubility increases rapidly with increasing temperature up to 48.9°C. at which the equilibrium crystalline phase changes from the nonyl to a lower hydrate. In the range of 48.9°C. up to about 86°C. (*8*, *9*) or 91.5°C. (*7*) where transition occurs to the monohydrate, the solubility increases with temperature and the equilibrium phase is either the hexahydrate or $Na_2S \cdot 5^1/_2 H_2O$, apparently depending upon whether the crystals are formed by evaporation of water at constant temperature or by cooling the solution from a higher temperature (*7*).

Using the apparatus sketched in Fig. 2, experiments on the ternary system Na_2CO_3–Na_2S–H_2O were conducted at 35, 60, 95, and 109°C. and the observed pressures and compositions of solution and liquid phases are reported in Table II. Solution phases were saturated with respect to sodium carbonate or sodium sulphide or both, so the compositions tabulated are those representative of limiting solubility.

Results are summarized in the triangular diagram comprising Fig. 3. Solubilities of salts in ternary mixtures lean in sodium sulphide are found to decrease moderately as the temperature is increased from 35 to 95°C. but this dependence lessens as the sodium sulphide concentration increases. Isothermal invariant points were located approximately at 35 and 60°C. by analyzing the several separated crystalline phases (Table II) and then interpolating to estimate the solution compositions corresponding to abrupt changes in relative proportions of carbonate to sulphide in crystalline phases. Isothermal invariant points at 95 and 109°C. were not located satisfactorily because of experimental difficulties, but it is probable that the corresponding saturated solutions contain sodium carbonate at only a small concentration, probably less than 2 wt. % Na_2CO_3, as indicated by the dotted lines shown in Fig. 3. On the sulphide rich side of the isothermal invariant points, limiting lines for sodium sulphide solubility have been drawn in at 35 and 60°C. and dotted lines are shown representing estimates of solubilities at several other temperatures.

A few experiments were conducted at about 95°C. in which sodium sulphate was present in small amounts along with sodium carbonate and sodium sulphide. These results are given in Table III. The solubility of the sodium sulphate was found to range from around 1.0 down to about 0.3 wt. % Na_2SO_4 as the solution was changed from a predominantly sodium sulphide to a predominantly sodium carbonate composition. Since the solution appeared to be saturated with respect to sodium sulphate, then in the presence of larger amounts of sodium sulphate, these same solubility limits would presumably still prevail while larger amounts of sodium sulphate would be separated in the crystalline phase.

The solution and also solid phase relationships for the Na_2CO_3-Na_2S-H_2O system at equilibrium at 60°C. are represented in Fig. 4 where the area ABCDE signifies permissible compositions for homogeneous liquids. Line BCD gives the composition of solutions saturated with respect to sodium carbonate, and area BCDF corresponds to two-phase systems containing a saturated liquid solution and crystalline sodium carbonate monohydrate designated by point F. Line DE shows the composition of solutions saturated with respect to sodium sulphide, and area DEG represents two-phase systems containing a saturated liquid solution and a crystalline Na_2S-6 H_2O or Na_2S-$5^1/_2$ H_2O phase designated by point G. Point D represents the composition of a solution saturated with respect to both sodium carbonate and sodium sulphide, and area DGHIF represents three-phase systems containing a saturated liquid of composition D and both sodium carbonate and sodium sulphide hydrates present as crystalline phases.

Thus if a smelt from a Tomlinson-type furnace contains sodium sulphide and sodium carbonate in a 1:1 mole ratio as indicated by Nugent and Boyer (*6*), and if the smelt is dissolved in water to yield a homogeneous solution of composition represented in Fig. 4 by point 0, then when water is removed by evaporation at 60°C., the solution composition changes along line OC until crystallization of sodium carbonate monohydrate begins at point C. As additional water is removed at 60°C., crystallization of the pure carbonate proceeds and the solution composition changes along line CD until point D is reached and crystallization of the sulphide begins. The solution compositions represented by points O, C, and D are shown in Table IV along with results of material balance calculations assuming that the initial mass of sodium sulphide in solution remains constant during the evaporation-crystallization process. The calculations indicate that evaporation of 68.3 lb. of water per 100 lb. of initial solution, followed by filtration, could yield about 8.3 lb. of $Na_2CO_3 \cdot H_2O$ crystals as well as 22.0 lb. of a solution containing 0.3 lb. Na_2CO_3 and 6.4 lb. Na_2S. Thus under these example conditions, about 95% of the sodium carbonate in the initial solution appears to be recoverable in pure crystalline form.

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Study of the Effects Produced by Drying an Unbleached Kraft Pulp Prior to a Single-Stage Hypochlorite Bleaching Treatment

MILTON H. VOELKER and MALCOLM N. MAY

A brief series of experimental investigations were conducted to determine the effects of air drying and oven drying on the bleaching characteristics of a kraft pulp. On the basis of this relatively limited exploratory work, it would appear that drying the kraft pulp prior to bleaching produced no adverse effects on the bleaching characteristics of the stock—o.e., the G.E. brightness, oven fade stability, bleaching time, and chemical demand characteristics actually tended to show improvement. Drying, however, adversely affected the bursting and tensile strength properties of the pulp both before and after bleaching.

THE effects of air drying and oven drying on the bleaching characteristics and the strength properties of a jack pine kraft pulp were briefly investigated by means of a single-stage hypochlorite bleaching treatment.

RAW MATERIALS

The materials employed in this exploratory study consisted of:

1. A commercially prepared Canadian jack pine kraft pulp. Oven-dry content = 41%; permanganate number (25-ml. basis) = 14.8; G.E. brightness = 26.7%. (This pulp, obtained in a wet lap form, was fluffed in the laboratory pulp breaker, placed in Pliofilm bags, and stored in the dark at 40°F. until it was required for the bleaching studies.)
2. Calcium hypochlorite bleach liquor prepared from granular high-test hypochlorite (approximate available chlorine content = 35 g.p.l.).
3. Solution of c.p. sodium hydroxide for pH control (concentration = 50 g.p.l.).

EXPERIMENTAL ATTACK

A series of five small-scale calcium hypochlorite bleaches, employing 0, 3, 5, 7, and 9% available chlorine were conducted on a sample of the undried (59% moisture) kraft pulp, a sample of air dried (6% moisture) kraft pulp, and a sample of oven-dried (10 hr. at 105°C., 2% moisture) kraft pulp.

The bleaching characteristics of the various unbleached pulps were subsequently evaluated by determining the G.E. brightness levels attained at various available chlorine consumptions, the quantity of sodium hydroxide required for pH control during the bleaching treatments, the time required for the bleaching treatments, and the yield and oven fade characteristics of the bleached pulps. In addition, the strength characteristics of the various bleached and unbleached stocks were evaluated by determining the Schopper-Riegler freeness and handsheet shrinkage properties of the pulps and the basis weight, caliper, apparent density, bursting strength, tearing strength, tensile strength, and zero-span tensile strength properties of TAPPI Standard handsheets prepared from the pulps.

DETAILED EXPERIMENTAL PROCEDURES FOR CONDUCTING SMALL-SCALE BLEACHES

(1) Bleaching conditions:
   (a) Pulp charge (oven-dry basis) = 45 g.
   (b) Pulp consistency (oven-dry pulp basis) = 12%.
   (c) Temperature = 35°C.
   (d) pH control point = 8.5 (pH maintained by the addition of 1.0-ml. doses of 50 g.p.l. NaOH whenever the pH dropped to a value of 8.5).
   (e) Bleaching time = to exhaustion of available chlorine.

(2) Washing and sampling procedure at end of bleach (these same procedures were utilized for the evaluation of unbleached pulps):
   (a) At the end of the bleaching treatment, the charge of bleached pulp was diluted to about 14.5 l. with filtered tap water.
   (b) The yield of bleached pulp was determined by obtaining the weight and consistency of the pulp slurry.
   (c) The pulp slurry was then dewatered on a filter paper placed on a Büchner funnel and the dewatered stock was subsequently rediluted to about 14 l. with filtered tap water.
   (d) The consistency of the pulp slurry was determined and two 2-g. (oven-dry basis) pulp samples were removed for duplicate Schopper-Riegler freeness determinations.
   (e) A 5-g. (oven-dry basis) pulp sample was removed, dewatered on a filter paper and split into two equal portions. Each portion was then diluted with distilled water and formed into a G.E. brightness sheet.
   (f) A 15-g. (oven-dry basis) pulp sample was diluted to about 10 l. and five TAPPI Standard handsheets were formed for strength testing (TAPPI Standard T 205 m-53) and three handsheets were prepared for shrinkage measurements (Routine Control Method 119).

RESULTS

The results of the experimental investigations have been summarized in Table I and Figs. 1 and 2. A study of these results indicates that:

1. Drying, particularly oven drying, increased the G.E. brightness of the unbleached pulp. It should be noted, however, that the pulp was dried in crumb form and, thus, the observed increase in brightness may have been a combined effect of drying and subsequent washing during the formation of brightness sheets.
2. Drying the pulp did not adversely affect the G.E. brightness levels attainable with a given consump-

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Table I. Results Obtained by Drying a Kraft Pulp Prior to a Hypochlorite Bleaching Treatment

Condition of unbleached pulp prior to bleaching treatment	*Hypo. bleach liq. avail. chlorine (based on o.d. pulp charge), %* Applied	Consumed	*G.E. brightness, %*	*G.E. brightness after oven fading, %*[a]	*Sodium hydrox. required for pH control, %*[b]	*Bleach. time, min.*	*Bleached pulp yield, %*	*Schopper-Riegler freeness, ml.*	*Handsheet shrinkage, %*[c]	*Basis wt. (25 × 40 − 500), lb.*	*Caliper, mils*	*Appar. dens.*	*Bursting strength, pt./100 lb.*	*Tear fact.*	*Tensile strength, lb./in./ 100 lb.*	*Zero-span tensile strength, lb./in./ 100 lb.*
Undried (59% moisture content)	0	0	26.7	...	...	...	...	870	2.91	45.5	4.0	11.4	65.5	2.11	40.4	88.8
	3	3	36.4	34.5	0.2	42	97	870	3.09	46.9	4.1	11.4	71.4	1.94	40.2	87.6
	5	5	51.0	46.9	0.8	58	101	860	3.23	47.3	4.1	11.5	72.1	1.90	42.7	83.1
	7	7	65.8	58.4	1.6	133	98	860	3.49	46.0	3.9	11.8	65.2	1.57	41.8	77.4
	9	9	74.4	66.6	2.3	240	98	870	3.81	45.·	3.9	11.6	62.1	1.17	40.9	64.5
Air dried (6% moisture content)	0	0	27.3	27.6	...	...	...	870	2.65	46.2	5.0	9.2	31.2	2.71	23.1	83.5
	3	3	37.6	35.8	0.1	20	97	875	2.83	45.8	4.5	10.2	43.9	2.88	28.7	83.8
	5	5	53.5	48.4	0.7	41	102	875	3.09	46.1	4.3	10.7	48.8	2.45	30.0	81.6
	7	7	66.1	59.8	1.3	132	97	865	3.09	46.0	4.4	10.5	42.2	2.13	29.8	64.8
	9	9	75.3	67.1	2.0	201	100	870	3.32	46.2	4.3	10.7	47.2	1.47	30.0	61.7
Oven dried 10 hr. at 105°C. (2% moisture content)	0	0	28.2	28.3	...	...	...	880	2.30	47.0	5.2	9.0	19.6	2.17	16.2	99.4
	3	3	38.1	36.8	0.3	20	98	875	2.41	47.3	5.0	9.5	26.2	2.60	20.0	107.0
	5	5	52.5	49.0	0.3	35	98	865	2.37	44.4	4.5	9.9	30.2	2.73	22.9	99.5
	7	7	67.1	61.8	1.4	86	96	870	2.76	44.9	4.5	10.0	34.3	2.49	24.4	90.9
	9	9	74.6	68.4	2.1	177	97	875	3.02	45.1	4.2	10.7	35.5	1.75	26.7	83.4

[a] The G.E. brightness sheets were faded for 1 hr. in an air-circulating oven maintained at 105°C.
[b] Oven dry pulp basis.
[c] The shrinkage tests were performed according to Routine Control Method 119. The oven-dried sheets, however, were pressed between blotters for 5 min. at 50 p.s.i. before measuring the shrinkage perimeter.

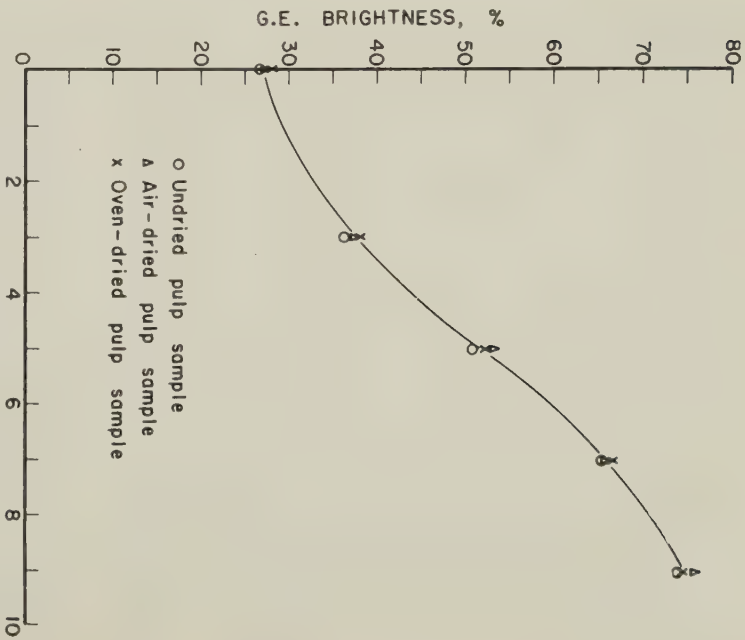

Fig. 1. Effect of drying on the bleaching properties of the pulp

tion of available chlorine and the dried pulps actually appeared to respond slightly better to hypochlorite bleaching than the undried pulp (see Fig. 1).

3. Air drying the unbleached pulp prior to bleaching produced essentially no effect on the oven-fading characteristics of the bleached pulps. Oven drying the pulp prior to bleaching, however, produced bleached pulps which had improved stability to oven fading (see Fig. 2).

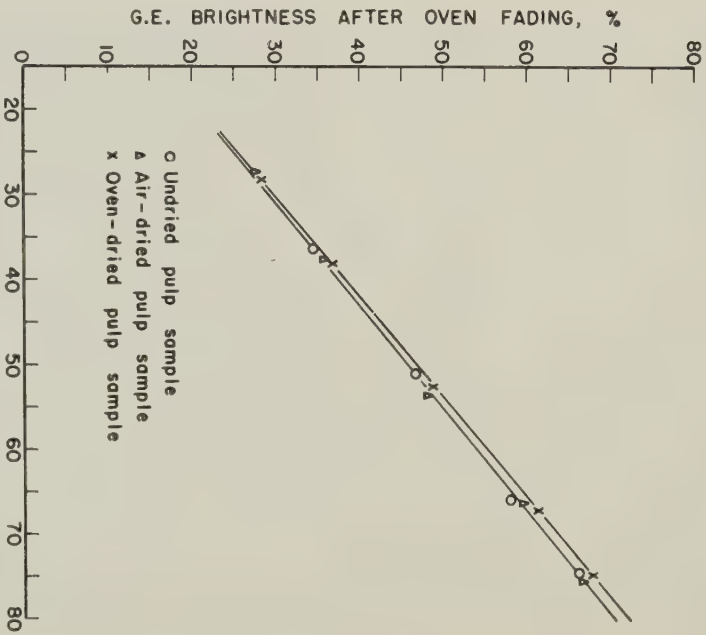

Fig. 2. Effect of predrying unbleached pulp on the G.E. brightness stability after bleaching

4. Drying—particularly oven drying—decreased the bleaching time required to bleach the pulp to a given brightness level. Also, the predrying operations tended to slightly reduce the quantity of caustic required during the bleaching treatment.

5. The drying operations did not greatly affect the freeness properties of the unbleached and bleached pulps. The air-drying pretreatment, however, tended to slightly reduce the zero-span tensile strength of the pulps and the oven-drying pretreatment apparently improved the zero-span tensile strength properties of the pulps.

6. In general, the drying operations produced unbleached and bleached pulps possessing higher tearing strength characteristics and lower handsheet shrinkage, apparent density, tensile strength, and bursting strength properties.

CONCLUSIONS AND DISCUSSION

The over-all effect of drying a pulp prior to bleaching was detrimental because it lowered the tensile and bursting strength of both the unbleached and the bleached pulps. Apparently, however, the drying operations produced no adverse effects on the bleaching characteristics of the stock—i.e., the G.E. brightness, oven-fade stability, bleaching time, and chemical demand characteristics actually tended to show improvement as a result of drying.

In view of this situation, an investigation of the cause for the improved bleaching characteristics of an oven-dried pulp might prove profitable. Conceivably, these improved characteristics (higher G.E. brightness, better oven-fade stability, and shorter bleaching periods) may be the result of the surface migration of certain pulp constituents during the drying operation. If this in fact were the case, it may be possible to produce the same effect by means other than drying, and thus simultaneously improve the bleaching characteristics and preserve the strength properties of the stock.

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Lead Tetraacetate Oxidation of Pulps and Hydrolyzed Pulps

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An attempt was made to confirm a postulate suggested by Steinmann and White (*6*) that mannose units in wood pulps are selectively oxidized by lead tetraacetate in glacial acetic acid. Analyses of the oxidized pulps showed that no selective oxidation of mannose units took place. It is suggested that the initial rapid oxidation is that of end groups of cellulose and hemicelluloses. Higher consumption of the oxidant by hydrolyzed pulps [usually containing less mannose units and of lower degree of polymerization (D.P.) as the hydrolysis increased] supports our postulate that the first stage of the oxidation is not due to mannose units, but rather to end groups.

Before discussing the subject of lead tetraacetate oxidations, let us briefly survey some broad aspects of the effect of mannose components in pulp on pulp properties.

Cellulose pulps usually contain a mannose component and there now seems little doubt that in softwoods, at least, the glucose polymers of cellulose are accompanied by a glucomannan which contains 70 to 80% mannose. Now mannose differs from glucose only in the configuration of the 2-carbon atom. This difference produces a *cis*-glycol rather than a *trans*-glycol. This might be expected to cause a stronger response in the polymers to reactions involving the glycol group. It is interesting that this is borne out in several cases.

For instance, it is possible to isolate mannose-containing polysaccharides by partial fractionation of certain holocelluloses, an insoluble copper or sodium copper complex being formed in cuprammonium cellulose solutions (*1–3*). Moreover, these mannose-containing polysaccharides can be extracted in large part from pulps by alkaline borate solutions, apparently as the soluble borate complex (*4*). The precipitation of glucomannans by barium hydroxide has also been recently attributed to the *cis*-hydroxyls (*5*). Finally, Steinmann, and White (*6*) have shown a correlation between the mannose-unit content of a dissolving pulp and the initial rapid oxidation of the pulp with lead tetraacetate. There is also an accumulative body of evidence that the nonglucose units (including mannose) in cellulose are among the factors involved in the acetylation behavior of the cellulose, influencing both haze and filtration characteristics (*6–9*).

In this preliminary study, we have extended the study of Steinmann and White to a higher range of mannose-unit content by working with paper-grade pulps (Table I). Steinmann and White simply determined mannose on a number of pulps and plotted the content against lead tetraacetate titration values under constant conditions. We carried this a stage further by determining the mannose content of the pulps both before and after the tetraacetate oxidation. The results cannot be clearly interpreted, as the conditions of the oxidation used by Steinmann and White (and later by us) do not produce oxidation of all the mannose. Glucose and xylose units are also oxidized, moreover.

Obviously the reactivity of the mannose unit is not

Table I. Characteristics of Pulps

Pulp source	*Pulping process*	*Alpha-cellulose, %*	*Beta-cellulose, %*	*Gamma-cellulose, %*	*Pentosan, %*	*Lignin, %*
I Cotton linters	...	95.8	2.43	1.34	Trace	..
II Spruce	Sulphite	84.5	4.00	10.55	4.10	0.37
III Southern pine	Sulphate	82.5	9.09	8.16	10.4	0.12
IV Gum	Sulphate	89.7	7.19	2.92	8.5	0.0
V Cotton linters	...	99.0	0.5	0.0	...	..

Pulps I–IV are in sheet form and pulp V in bulk form.

Kei Matsuzaki, Faculty of Engineering, University of Tokyo, Tokyo, Japan, and Kyle Ward, Jr., The Institute of Paper Chemistry, Appleton, Wis. This work was performed at The Institute of Paper Chemistry.

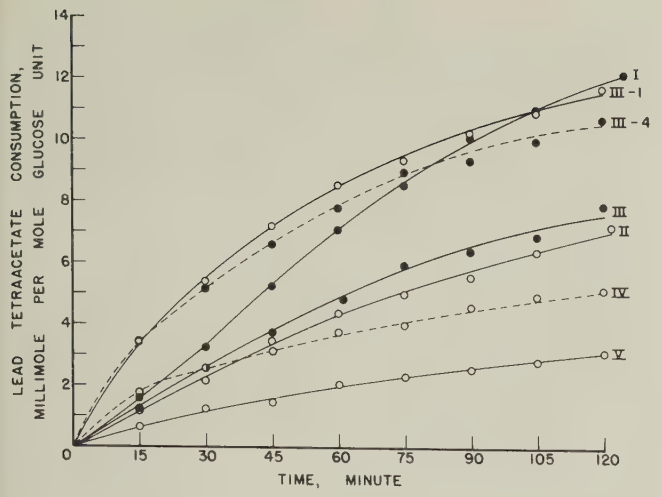

Fig. 1. Lead tetraacetate oxidation of pulps. I. Cotton linters pulp; II. Spruce sulphite pulp; III. Southern pine sulphate pulp; IV. Gum sulphate pulp; V. Cotton linters; III-1 and -4. Southern pine sulphate pulp hydrolyzed for 1 and 7 hr., respectively

the only factor influencing the titration of cellulose with lead tetraacetate, as Steinmann and White appreciated. In general, the correlation shown by these authors to exist between anhydromannose content and tetraacetate consumption held with our pulps, but pulp I is a conspicuous exception.

Two other possible factors are the effect of fine structure on accessibility and the increased reactivity of end groups (*10*). Failure to oxidize central units in the cellulose may be indicated by our failure to detect erythrose in the hydrolyzate of an oxidized cotton linter. Our brief, preliminary study of hydrolysis of pulps (Tables II and III) also bears on these points. The preponderance of nonglucose units in the accessible regions (*11*) is borne out by the results in Table III. Only one of these hydrolyzed pulps was analyzed for mannose-unit content after tetraacetate oxidation, but the result shows much more proportionate destruction of this sugar component than in the original pulp (Table II). The rate of initial tetraacetate consumption is also increased by hydrolysis (Figs. 1 and 2). The more rapid removal of xylan from the pulp by hydrolysis is borne out especially by the hydrolysis of Pulp III (Table III). It is so rapidly removed, at first, that the percentage of anhydromannose present actually increases.

References to accessibility in the foregoing signify accessibility to acetic acid. The difference in swelling behavior of the media probably influences any differences between lead tetraacetate and periodic acid oxidations. It may be that the rates of lead tetraacetate oxidation correlate with those of the first stage of acetylation and the matter should be investigated.

While the over-all mechanism of tetraacetate oxidation is complicated, it seems probable from these preliminary results that the first rapid oxidation is that of the end groups in the accessible regions and the correlation with mannose and xylose content may arise from the higher proportion of these sugars in such regions. The later slow oxidation may result from secondary oxidations and from breakdown of the less accessible molecules. The more rapid oxidation of hydrolyzed pulps probably arises from the presence of more accessible end groups.

The whole question is being further studied at present by Mr. Detrick at The Institute of Paper Chemistry.

Table II. Nonglucose Units Content in Pulps Before and After the Lead Tetraacetate Oxidation

Pulp	*Mannose units content, %*		*Xylose units content, %*	
	Before	*After*	*Before*	*After*
II	5.8	5.2	4.1	3.5
III	7.7	7.2	10.9	11.3
IV	1.0	0.9	8.5	8.2
III-4	3.0	1.5	0.6	0.8

Percentages are based on reducible carbohydrates in the hydrolyzate of the pulps.

Table III. Nonglucose Units Content and Yield of Acid-Hydrolyzed Pulps

Pulp	*Time of hydrolysis, hr.*	*Yield, %*	*Mannose units, %*	*Xylose units, %*
II	...	100	5.8	4.5
II-1	1	84.3	3.1	2.0
II-2	3	79.7	1.4	1.0
II-3	5	76.3	1.5	1.0
II-4	7	70.9	0.5	0.6
III	...	100	7.7	10.9
III-1	1	84.3	8.6	1.3
III-2	3	76.7	5.3	1.1
III-3	5	70.4	4.1	0.7
III-4	7	66.9	3.0	0.6

EXPERIMENTAL

Materials. The pulps used were commercial pulps. Numbers I–V are characterized in Table I. Pulp VI was a sulphite pulp from red pine (*P. densiflora S and Z*) and pulp VII a linters acetylation pulp.

Methods. TAPPI methods were used to obtain the values in Table I for alpha-cellulose (*12*), beta and gamma-cellulose (*13*), pentosans (*14*), and lignin (*15*). D.P.'s were determined viscometrically (*16*) using a Km. value of 8.0 times 10^{-4}.

Lead Tetraacetate Oxidation of Pulps Shown in Fig. 1. Approximately 0.005 mol. of the dried pulp was charged into a 500-ml. flask equipped with a sealed stirrer. After 2 hrs. stirring at 30°C. in 50 ml. of glacial acetic acid, 15 ml. of 0.1 mol. of lead tetraacetate-glacial acetic acid solution were added. Five milliliters were

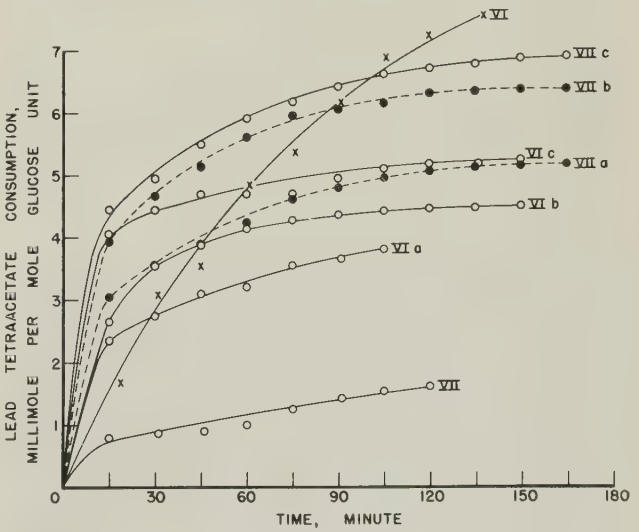

Fig. 2. Lead tetraacetate oxidation of pulps and hydrolyzed pulps. VI. Sulphite pulp; VI-a, -b, and -c. Sulphite pulp hydrolyzed for 1, 3, and 5 hr., respectively (D.P. 165, 157, and 147, respectively); VII. Cotton linters; VII-a, -b, and -c. Cotton linters hydrolyzed for 1, 3, and 5 hr., respectively (D.P. 147, 146, and 144, respectively)

pipetted out at 15-min. intervals, 10 ml. of potassium iodide-sodium acetate solution added and the solution titrated with 0.01 N sodium thiosulphate solution using Thyodene as indicator.

After 2 hrs., excess of the potassium iodide-sodium acetate solution was added to the pulp slurry, and the iodine produced was reduced with thiosulphate solution. The oxidized pulp was filtered, washed, and dried.

Lead Tetraacetate Oxidation of Pulps Shown in Fig. 2. The oxidations were run at 31 ± 1°C. in the same way as above doubling the quantities of the samples and solutions, except that 25 ml. of 0.1 mol. solution of lead tetraacetate were added to the pulps instead of 30 ml.

Acid Hydrolysis of Pulps Shown in Table III and Fig. 2. Two grams of dried pulp were hydrolyzed with 200 ml. of 4 N hydrochloric acid solution at 98°C. for 1, 3, 5, and 7 hrs. After predetermined times, the hydrolyzed pulps were filtered on fritted-glass filters, washed with hot water and acetone, and dried.

Acid Hydrolysis of Pulps Shown in Fig. 2. Five grams of dried pulp were hydrolyzed with 400 ml. of 2 N sulphuric acid solution at boiling temperature for 1, 3, and 5 hr. The residues were filtered on fritted-glass filters, washed and dried.

Mannose and Xylose Determinations. The method used was that used by Matsuzaki and Ward (*16*) in a previous study of nitrated celluloses.

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Apparatus for Topographic Studies of Paper and Paperboard Surfaces

HAROLD J. ANDERSON

Smoothness is an important surface characteristic in printing and converting paper and paperboard. Available methods for determining surface smoothness are not able to describe completely paper and paperboard topography. An apparatus for photographing paper and paperboard surfaces is described. Photomacrographs are taken of a $^3/_8$ by $^1/_2$-in. area using uniform, annular, low angle (3 to 5°) illumination. These clearly show the topography of the paper or paperboard surface without the use of any auxiliary shadowing techniques. Examination of paper and paperboard surfaces before and after printing by use of this technique can lead to a better understanding of the importance of smoothness in the printability of these products. Eight illustrations are presented, two of the apparatus and six photomacrographs of paper and paperboard surfaces.

The Pulp, Paper and Board Industry Report (*1*) for 1957 shows that more than one-half of the paper and paperboard produced last year was printed or converted. Surface characteristics are of great importance in printing and converting operations. Smoothness, considered one of the more important surface characteristics, is necessary for faithful reproduction of letterpress and rotogravure printing. Smoothness also improves film continuity in waxing or laminating papers and paperboards. Actually most papermaking processes aim toward a development of smoother surfaces for the finished product. Therefore, the paper industry requires methods for determining the degree of smoothness of their products.

Usually smoothness measurements involve airflow or optical methods. The airflow method measures the volume of air which passes between the sheet and a reference surface under constant pressure. Bekk (*2*), Gurley (*3*), and Bendsten (*4*) are airflow-type instruments which vary only in the method of applying the same principle. Optical methods for determining degrees of smoothness have been described by Chapman (*5*), Halliday (*6*), and Bernstein (*7*). Chapman's method involves pressing a prism against the specimen, illuminating the prism and measuring the intensities of the light diffusely and specularly reflected from its lower face. The ratio of these quantities depends upon the contact between the lower face and the paper and is thus an expression of surface uniformity, or smoothness. Halliday's method allows visual examination of paper and paperboard surfaces through directional low angle illumination. Bernstein applied shadowing techniques for the same purpose.

Although much can be learned in applying these methods, they are not able to produce a complete story of the paper and paperboard topography. Airflow methods give numerical values for degrees of smoothness but fail to describe the actual variance in the contour of the surface. In other words, identical airflow rates could be obtained from a surface having a small number of hills and valleys of large magnitude

Harold J. Anderson, Sr. Scientist, Marathon, a Division of American Can Co., Menasha, Wis.

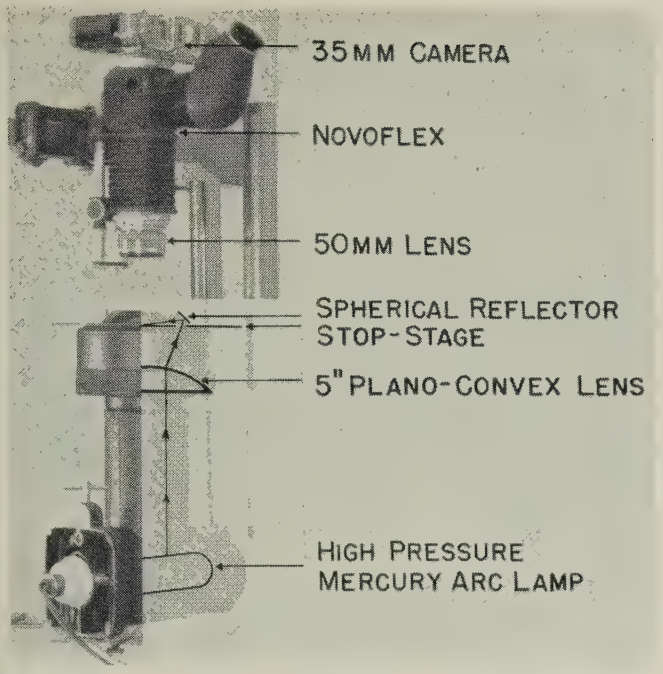

Fig. 1. Assembled apparatus for illuminating and photographing paper and paperboard surfaces

and a surface with a large number of hills and valleys of smaller magnitude. Chapman's method shows area of contact but fails to describe depth differences in non-contacting areas. Halliday's directional low angle illumination gives exaggerated shadowing which can lead to erroneous conclusions of surface topography.

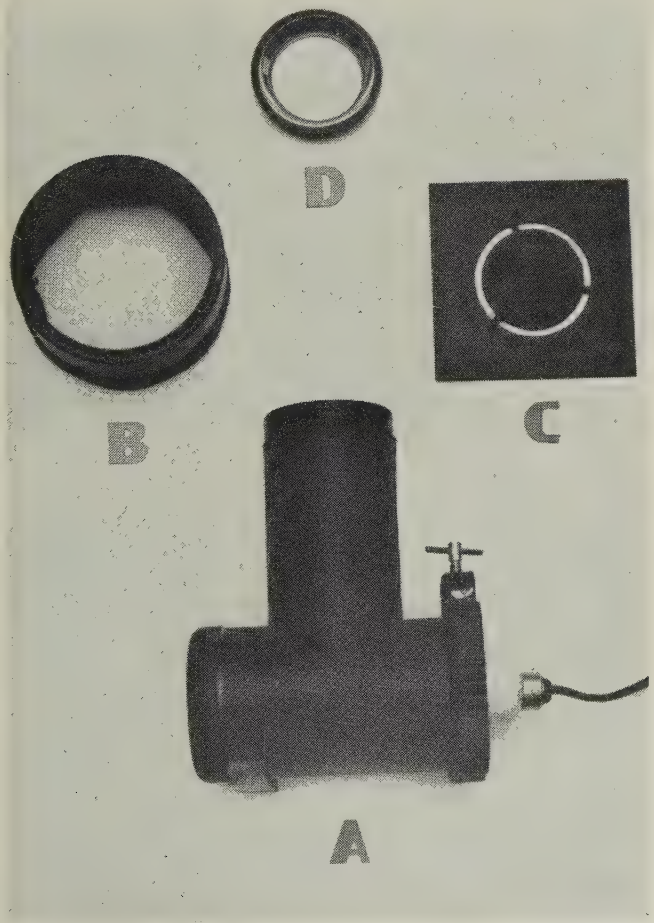

Fig. 2. Components of oblique annular illuminator

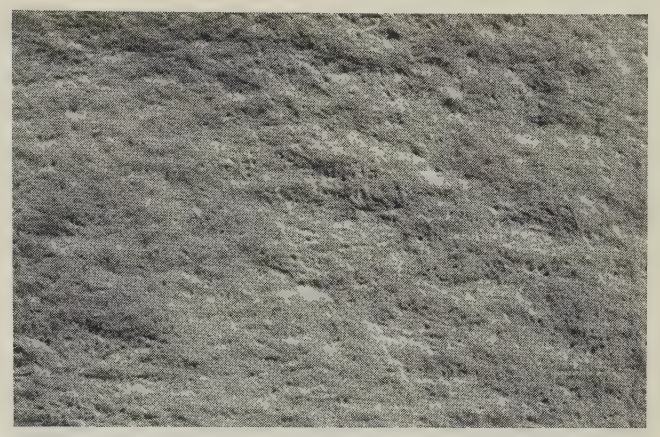

Fig. 3. Size press wash coated paperboard

Bernstein's use of extraneous materials to produce sufficient contrast for observing surface detail results in an obscure impression of the surface examined.

In searching for a method to supplement these tests, it was decided that visual examination of the surfaces would best reveal the types and degrees of the smoothness. One available method, the oblique annular illumination obtained with Leitz Ultropak and Bausch & Lomb Trivert microscopes, gives the desired lighting but the area of sample which can be examined or photographed is too small to be representative of the total surface.

To produce satisfactory topographic photomacrographs, an apparatus should provide: (1) large examining area—the larger the examining area the more representative of the whole it becomes; (2) uniform, annular, low angle (3 to 5°) illumination to prevent exaggerated shadowing which can lead to erroneous conclusions of surface topography; and (3) the opportunity for examination of paper and board surface before and after printing. Observing ink coverage after printing at various pressures compensates for the inability to examine a sheet under pressure. An oblique annular illuminator was designed and assembled to fulfill these requirements.

APPARATUS

Figure 1 is the assembled apparatus for illuminating and photographing paper and paperboard surfaces. Figure 2 shows the individual components of this apparatus. A high-pressure mercury arc lamp (A) is the UV light source. The 5 in. planoconvex lens (B)

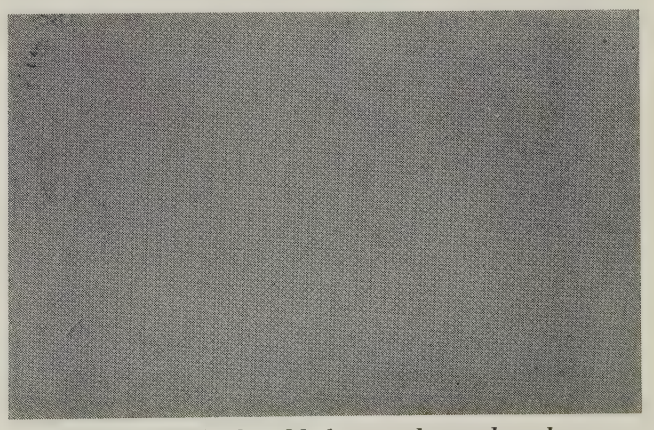

Fig. 4. Trailing blade coated paperboard

directs light to a stop stage (C). The stop stage cuts out stray light, permitting light to pass through a circular area directly below the spherical reflector, and supports the sample under examination. The light is

Fig. 5. Roll coated paperboard

reflected at a low angle (3 to 5°) to the surface of the sample by the spherical reflector (D). This reflector is a spherical sector with 2 in. convex radius of curvature, 3 1/4 in. outside diam. and 2 1/4 in. center hole diam. Photographic equipment includes a Zeiss Ikon camera equipped with Novoflex bellows extension and a 50 mm. Sonnar lens.

PROCEDURE

The samples of paper or paperboard are cut into 2 in. squares. Paper samples are held flat by mounting them on glass slides coated with Kodaflat solution. Paperboard samples will normally lie flat if cut carefully. The sample to be photographed is placed on the stop stage and the camera is focused. The lens is stopped down to F-16 to insure maximum resolution before the exposures are made. Best results are obtained using Kodak Micro File, an extremely fine grain, slow, pancromatic emulsion film. Since it is a slow film (Tungsten Exposure Index of 16) rather long exposures are required and a rigid photographic arrangement is necessary. Exposures range from 30 sec. to 2 min., depending on the sample photographed,i.e.,

Fig. 6. Uncoated paper

printed or unprinted, and/or use of filters. In photographing printed samples, the use of yellow inks give best photographic results due to proper contrast balance between ink and paper. Proper filters can also be used to produce this contrast balance. The area of sample photographed is 3/8 by 1/2 in. The final print size is 5 by 7 in., a total magnification of 14 diam.

CONCLUSIONS

Important information about the topography of paper and paperboard surfaces can be obtained by

Fig. 7. Trailing blade coated paper

examining photomacrographs obtained with the apparatus described. Figures 3 through 8 demonstrate the ability of this type of illumination to reveal degrees and types of surface smoothness. Figures 3 through 5 show smoothness differences obtained when paperboard is coated by three different coating processes. Figures 6 and 7 compare an uncoated with a coated paper and Fig. 8 shows the embossing action of letterpress printing on a coated paper.

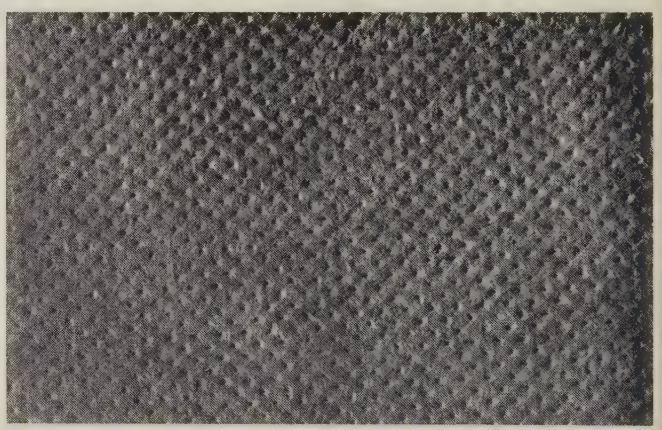

Fig. 8. Coated paper printed by letterpress printing process

Examination of these surfaces before and after printing will lead to a better understanding of the role of smoothness in the printability of paper and paperboard.

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RECEIVED Sept. 12, 1958.

ASSOCIATION NEWS AND EVENTS

National Conferences

Tenth Testing Conference, Multnomah Hotel, Portland, Ore., Aug. 17–21, 1959.

Fundamental Research-Wet Strength Conference, I.P.C., Appleton, Wis., Sept. 9–11, 1959.

Ninth Corrugated Containers Conference, Jung Hotel, New Orleans, La., Sept. 15–17, 1959.

Fourteenth Paper-Plastics Conference, Edgewater Beach Hotel, Chicago, Ill., Sept. 21–23, 1959.

Fourteenth Engineering Conference, Penn-Sheraton Hotel, Pittsburgh, Pa., Oct. 12–15, 1959.

Thirteenth Alkaline Pulping Conference, Robert Meyer Hotel, Jacksonville, Fla., Nov. 4–6, 1959.

Other 1959 Conferences

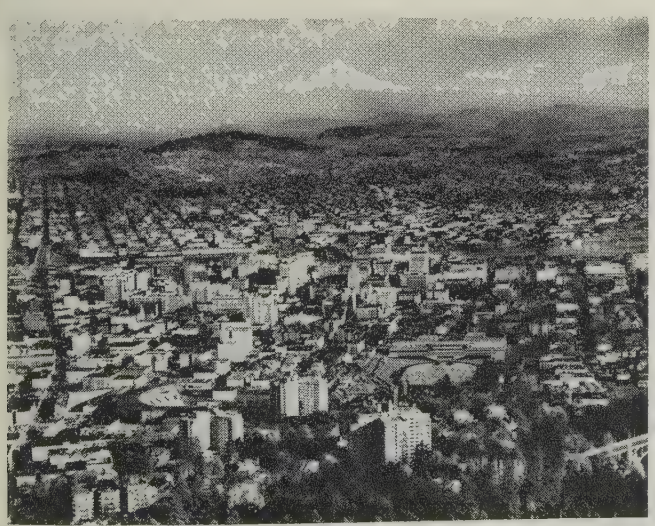
Sept. 13–18	Am. Chem. Society, Atlantic City, N. J.
Oct. 26–28	Packaging Institute, Statler Hotel, New York, N. Y.
Nov. 9–1	National Paperboard Assoc., New York, N. Y.

Tenth Testing Conference

The Multnomah Hotel in the center of Portland, Ore., will be the site of the Tenth TAPPI Testing Conference, Aug. 17 to 21, 1959.

The conference will open on Monday with two outstanding mill visits. Visitors will have a choice of (1) the largest completely integrated wood products mill in the world. This is the Weyerhaeuser Timber Co. mill in Longview, Wash. On one 800-acre mill site TAPPI testers will see three lumber mills, a plywood plant, four pulp mills, a chemical plant and extensive research facilities or (2) the fabulous Research and Development Center of the Crown Zellerbach Corp. in Camas, Wash. This is the main center of research from the tree through spent liquor chemicals to finished paper in every imaginable form.

The next 3 days will be devoted to carefully prepared and useful papers on all types of testing. The theme of the conference is "Pulp Testing"; however, all types of testing will come under discussion. One of the high lights of the technical sessions will be the meetings on Wednesday which will be joint meetings with the Pacific Section of TAPPI. The Pacific Section is celebrating its 30th Anniversary and they will be out in force to help make this an outstanding conference. The complete program is printed below.



Portland, Ore., site of the Tenth Testing Conference

The conference will close on Friday with a trip to one of the large logging operations in the virgin forests of Oregon. This is the Clatsop Tree Farm of the Crown Zellerbach Corp. It covers 184,000 acres along the northern coast of Oregon. Some really big trees, will be seen as the world's largest Douglas-fir tree is located in this tree farm. This tree is nearly 16 ft. in diameter at the ground, 225 ft. high to a broken top 30 in. in diameter at the break, and it is estimated to be about 1000 years old.

Wives and children are welcome for the mill visits and the woods trip.

Registrations should be addressed to: Miss Kay Fralick, c/o Morden Machines Co., 3420 S. W. Macadam Ave., Portland 1, Ore.

TECHNICAL PROGRAM

1. "Report on the Interlaboratory Testing of Pentosan Methods," by W. K. Wilson, National Bureau of Standards, Washington, D. C.
2. "Interlaboratory Variations of the Tearing Test," by T. W. Lashof, National Bureau of Standards, Washington, D. C.
3. "Gas Chromatographic Analysis of Hydrogen Sulphide, Sulphur Dioxide, Mercaptans and Alkyl Sulphides and Disulphides," by Donald F. Adams and Robert K. Koppe, Division of Industrial Research, State College of Washington, Pullman, Wash.
4. "The Boxboard Research and Development Association Scorability Tester," by R. L. Lewis and Clyde Eckhart of the Ohio Boxboard Co., Rittman, Ohio, and A. T. Luey of the Boxboard Research and Development Association, Chicago, Ill.
5. "The Testing of Papers Containing Fluorescent Brighteners," J. M. Patek, Eastman Kodak Co., Rochester, N. Y. (to be ready by Dr. Richard Hunter).
6. "Instrumental Measurement of Color and Color Difference in the Paper Industry," by M. W. Westgate, Gardner Laboratories Inc., Bethesda, Md.
7. "Printability of Newsprint," by G. L. Larocque, *The New York News,* New York, N. Y.
8. "The Effect of Electrolyte in the Valley Beater Test," by B. B. Thomas, Rayonier Inc., Shelton, Wash.
9. "Effect of Aging in the TAPPI Reference Pulp," by C. E. Brandon, Miami University, Oxford, Ohio.
10. "Experience with the 80-Grit Touch-Up Method for Laboratory Beater Tackle Conditioning," by F. Dinger, Puget Sound Pulp & Timber Co., Bellingham, Wash.
11. "Use of Commercial-Size Refiner for Pulp Evaluation," by J. L. McAndie, Morden Machines Co., Portland, Ore.
12. Panel: Pulp Evaluation, Roy P. Whitney, dean, The Institute of Paper Chemistry, Appleton, Wis., *Moderator.* Panelists will include outstanding experts from the United States and abroad.

Fiber Attraction and Bonding Symposium

A symposium on the Fundamentals of Fiber Attraction and Bonding will be held Sept. 9–11, 1959, at The Institute of Paper Chemistry, Appleton, Wis. Jointly sponsored by the Fundamental Research and Wet Strength and Interfiber Bonding Committees of TAPPI, the symposium is being arranged by the following committee:

Co-Chairmen: J. W. Swanson and R. P. Whitney, The Institute of Paper Chemistry, Appleton, Wis.
Program Chairman: R. N. Griesheimer, The Mead Corp., Chillicothe, Ohio
Local Arrangements Chairman: J. J. Shipman, Kimberly-Clark Corp., Neenah, Wis.
Publicity Chairman: C. S. Maxwell, American Cyanamid Co., Stamford, Conn.

Advance registration for the symposium should be made as soon as possible, using the registration form printed elsewhere on this page. Information concerning hotels, motels, and transportation is given following the program.

WEDNESDAY, SEPT. 9, 1959

8:30 a.m. Registration

9:30 a.m. Session I, Principles of Adhesion

Chairman, Roy P. Whitney, The Institute of Paper Chemistry, Appleton, Wis.

1. "Fundamentals of Adhesion," by Alfred H. Nissan, Rensselaer Polytechnic Institute, Rensselaer, N. Y.
2. "Structural Aspects of Bonding," by J. A. Van den Akker, The Institute of Paper Chemistry, Appleton, Wis.

12:15 p.m. Luncheon

2:00 p.m. Session II, Development of Wet Web Strength

Chairman, R. N. Griesheimer, The Mead Corp., Chillicothe, Ohio

1. "Fiber Agglomeration and Dewatering," by W. L. Ingmanson and S. T. Han, The Institute of Paper Chemistry, Appleton, Wis.
2. "Wet Web Strength," by W. Brecht and H. Erfurt, Institut für Papierfabrikation, Technische Hochschule, Darmstadt, Germany.
3. "Some Aspects of Wet Web Behavior," by A. Robertson, Pulp and Paper Research Institute of Canada, Montreal, Que.

THURSDAY, SEPT. 10, 1959

9:00 a.m. Session III, Fiber Properties Affecting Adhesion

Chairman, G. K. Dickerman, Consolidated Water Power and Paper Co., Wisconsin Rapids, Wis.

1. "Flexibility of Fibers," by S. F. Kurath, The Institute of Paper Chemistry, Appleton, Wis.
2. "Dimensional Stabilization of Paper," by W. E. Cohen, A. J. Stamm, and D. J. Fahey, U. S. Forest Products Laboratory, Madison, Wis.
3. "Fiber Geometry as Related to Adhesion," by Speaker to be announced.

12:15 p.m. Luncheon

2:00 p.m. Session IV, Development of Bonds

Chairman, R. A. A. Hentschel, E. I. du Pont Nemours & Co., Inc., Wilmington, Del.

1. "Mechanism of Bonding," by W. Boyd Campbell, Consultant, Montreal, Que.
2. "Fiber Surface Area and Bonded Area," by J. W. Swanson, The Institute of Paper Chemistry, Appleton, Wis.
3. "Bonding in Synthetic Fiber Papers," by R. A. A. Hentschel, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

FRIDAY, SEPT. 11, 1959

9:00 a.m. Session V, Role of Additives in Bonding

Chairman, K. W. Britt, Scott Paper Co., Chester, Pa.

1. "Polysaccharide Adhesives," by M. L. Cushing, A. E. Staley Manufacturing Co., Decatur, Ill.
2. "Mechanism of Retention of Resin Additives," by E. F. Thode, J. W. Swanson, S. F. Kurath, The Institute of Paper Chemistry, Appleton, Wis.
3. "Elastomeric Binders," by Paul J. McLaughlin, Rohm & Haas Co., Philadelphia, Pa.

12:15 p.m. Official Luncheon

Chairman, R. P. Whitney, The Institute of Paper Chemistry, Appleton, Wis.

2:30 p.m. Session VI, Panel Discussion and Summary

Chairman, J. W. Swanson, The Institute of Paper Chemistry, Appleton, Wis.

Panel to be composed of speakers at previous sessions.

Housing and Transportation Information in Appleton, Neenah, Menasha Area

Hotels

Hotel Appleton, 127 North Appleton St., Appleton
John Balliet Hotel, 124 West Washington St., Appleton
Conway Hotel, 128 North Oneida St., Appleton
Menasha Hotel, 177 Main St., Menasha
Valley Inn, 129 E. Wisconsin Ave., Neenah

Motels

Alamo Plaza, Highway 41, Appleton
Biggars Motel, 3730 West College Ave.
Bloomer's Motel, 2603 North Richmond St., Appleton
Dreamland Court, Highway 41, Appleton
El-Kay Motel, 420 West Northland Ave., Appleton
El Rancho Motel, 138 East Northland, Appleton
Nee Vin Motel, Highway 41, Neenah
Restwell Motel, Highway 41, Little Chute
Sky-Vu Motel, Route 1, Appleton
Twin City Motel, Highway 41, Neenah
Woodland Motel, Lake Road, Appleton

Transportation

Appleton is served by the Chicago & Northwestern Railroad with several trains daily to and from Chicago.

Although Appleton is not served currently by commercial airlines, it is expected that commercial service will be inaugurated during the summer of 1959. Appleton is accessible by North Central Airlines from either Winnebago County Airport at Oshkosh or Austin Straubel Field at Green Bay. Oshkosh is approximately 25 miles south of Appleton, and Green Bay is approximately 30 miles north of Appleton. Each airport has limousine service to Appleton, and there are rental cars available at the airport or in the city of Appleton.

PREREGISTRATION FORM

Symposium on

Fundamentals of Fiber Attraction and Bonding

Sponsored Jointly by the Fundamental Research Committee and the Wet Strength and Interfiber Bonding Committee of TAPPI

The Institute of Paper Chemistry, Appleton, Wis.
Sept. 9, 10, and 11, 1959

Name _____
(Print or type)

Title or Position _____
(Company or organization)

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(Address)

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Member of National TAPPI _____
Nonmember of National TAPPI _____ (Please check)
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TAPPI Members $15.00 _____
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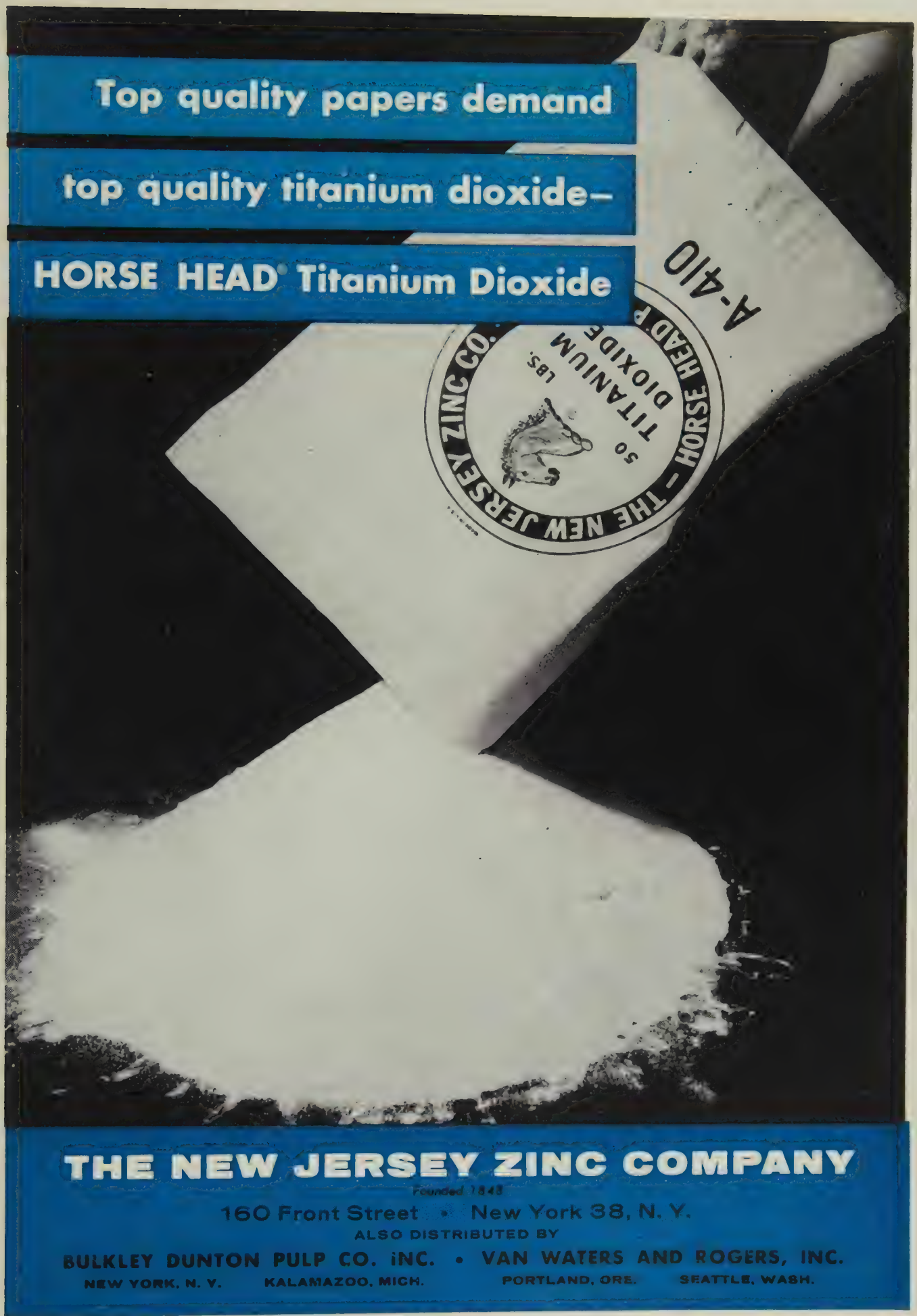
* Please make check payable to The Institute of Paper Chemistry and send with this registration form to: Dr. Roy P. Whitney, The Institute of Paper Chemistry, Appleton, Wis.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Registration fee includes participation in all technical sessions and luncheon on each of the three days of the symposium.

Registration fees will be refunded to those finding it necessary to change plans if requested before Sept. 8, 1959.

Because facilities are limited to approximately 225 persons, early preregistration is urged. Registrations will be accepted in the order received.

Fourteenth Plastics-Paper Conference

The Fourteenth Plastics-Paper Conference of the Technical Association of the Pulp and Paper Industry will take place at the Edgewater Beach Hotel, Chicago, Sept. 21 to 23, 1959. Walter L. Hardy, International Minerals and Chemical Corp, Chicago, general conference chairman, has announced plans for five technical sessions.

The first technical session will include a final report and a five-year summary of the work done at the College of Forestry, State University of New York at Syracuse on the Permeability of Plastic-Treated Paper to Gases and Liquids, Tappi Research Project No. 120. Piggy-back polymers, nylon extrusion coating, and patent law will also be discussed at this session.

The second session will be a panel discussion on converting and will include remarks on the present and future of

1. Waxed papers
2. Saturation papers
3. Asphalt laminated papers
4. Abrasive papers
5. Plastic coated papers
6. Gummed papers

The Tuesday morning session will be on production and will feature papers on new coating techniques, quantitative coating control, waste control, statistical control, and a paper on production techniques involved in manufacturing polyethylene coated board.

A number of papers are being considered by t for presentation at the fourth technical session. The fifth session is being sponsored by the Plastic Laminates Committee on Wednesday morning.

Mr. Hardy advises that requests for hotel reservations should be directed to the Edgewater Beach Hotel.

Fourteenth Engineering Conference

TENTATIVE PROGRAM

October 11–15, 1959
Hotel Penn Sheraton, Pittsburgh, Pa.

SUNDAY, OCT. 11, 1959

10:00 a.m.–12:00 Noon. Staff Advisory Committee (Parlor B)
1:00 p.m.–5:00 p.m. Committee Consultations (Parlor B)
4:00 p.m.–8:00 p.m. Registration (Fort Duquesne Room)

MONDAY, OCT. 12, 1959

8:00 a.m.–5:00 p.m. Registration (Fort Duquesne Room)
9:00 a.m. First Session, General (Urban Room)

Opening remarks, J. R. Curtis, Scott Paper Co., *General Chairman*

9:15 a.m.–12:00 Noon. Second Session (Urban Room)

Steam and Power, R. V. Knapp, Mosinee Paper Co., Mosinee, Wis., *Chairman*

1. "Progress Report on Atomic Power," by J. W. Magee, Jr., and J. H. Wright, Westinghouse Electric Corp., Phila., Pa.
2. "Allocation of Costs for Process Steam and Power in Paper Mill Power Plants," by G. D. Farrar, General Electric Co., Atlanta, Ga.

Panel Discussion: Economic Limitations of Pressures and Temperatures for Pulp and Paper Mills. Moderator: J. G. Hoad, John G. Hoad & Assoc., Ypsilanti, Mich.

9:15 a.m.–12:00 Noon. Third Session (Monongahela Room)

Sanitary Engineering, W. A. Moggio, Lake States Yeast Corp., Rhinelander, Wis., *Chairman*

Theme: "Air—Its Role in Waste Treatment and Disposal"

1. "Flotation Methods," by L. L. Klinger, Central States Engineer, Inc., Appleton, Wis.
2. "Oxidation Lagoons," Speaker from: National Council for Stream Improvement, New York, N. Y.
3. "River Reaeration," Speaker from: Sulphite Pulp Mfgr's. Research League, Appleton, Wis.

12:30 p.m.–1:45 p.m. Committee Luncheons
Civil Engineering (Grant Room)
Drying (Sky Room)
Engineering Economics (Club Room)
Industrial Engineering and Materials Handling (Park View Room)
Maintenance Engineering (Room 566)
Sanitary Engineering (Room 766)

2:00 p.m.–5:00 p.m. Fourth Session (Urban Room)

Electrical Engineering, R. F. Sorenson, St. Regis Paper Co., Jacksonville, Fla., *Chairman*

1. "Electrical Control of Fourdrinier Helper Drives," by S. J. Campbell, Westinghouse, Pittsburgh, Pa., and D. C. Pier, Beloit Iron Works, Beloit, Wis.
2. "Semiconductor Rectifier Power Supplies in the Paper Industry," by G. E. Shaad, General Electric Co., Schenectady, N. Y.
3. "Safety in Mill Electrical Work," by M. L. Perkins, Fraser Paper Co., Madawaska, Me.
4. "Power Transfer Within Wet Felts of Paper Machines," by M. J. Osborne, Bowaters Southern Paper Corp., Calhoun, Tenn., and I. Peters, F. C. Huyck Co., Rensselaer, N. Y.

2:00 p.m.–5:00 p.m. Fifth Session (Monongahela Room)

Mechanical Engineering, M. N. Davis, Kimberly-Clark Corp., Neenah, Wis., *Chairman*

6:00 p.m. Process Instrumentation Committee (Parlor B)

TUESDAY, OCT. 13, 1959

8:00 a.m.–5:00 p.m. Registration (Duquesne Eoom)
9:00 a.m.–12:00 Noon. Sixth Session (Urban Room)

Civil Engineering, W. Pittam, Stone and Webster Engineering, Inc., Boston, Mass., *Chairman*

9:00 a.m.–12:00 Noon. Seventh Session (Allegheny Room)

Maintenance Engineering, R. Q. Conner, The Crossett Co., Crossett, Ark., *Chairman*

9:00 a.m.–12:00 Noon. Eighth Session (Monongahela Room)

Process Instrumentation, J. K. Powell, Bowaters Southern Paper Corp., Calhoun, Tenn., *Chairman*

1. "Experimental Recovery Unit." (Speaker not Confirmed)
2. "A Versatile New Consistency Regulator," by K. I. Mumme and N. W. Swanson of Kimberly-Clark, Neenah, Wis.

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3. "How One Mill Handles Instrumentation (Engineering, Specifications, Applications, Maintenance)." Speaker not confirmed.

12:30 p.m.–1:45 p.m. Committee Luncheons
Chemical Engineering (Room 766)
Corrosion (Aero Room)
Electrical Engineering (Grant Room)
Fluid Mechanics (Room 566)
Mechanical Engineering (Park View Room)
Steam and Power (Sky Room)

2:00 p.m.–5:00 p.m. Ninth Session (Urban Room)

Fluid Mechanics, N. SHOUMATOFF, West Virginia Pulp & Paper, Co., New York, N. Y., *Chairman*

1. "Patterns of Circumferential Flow in Cylindrical Annuli," by A. H. Nissan and F. C. Haas, Rensselaer Polytechnic Inst., Troy, N. Y.
2. "Flow Instability on the Fourdrinier Wire-Progress Report of TAPPI Project No. 156," by C. S. Yih and A. C. Spengos, Univ. of Michigan, Ann Arbor, Mich.
3. "Book Paper Inlet Performance with Relation to the Fourdrinier Wire," by J. C. Nelson, Kimberly Clark Corp., Neenah, Wis. (Speaker to be confirmed)
4. "The Effects of Fibers on Velocity Distribution, Turbulence and Flow Resistance of Dilute Suspensions—Report of TAPPI Project No. 147," by J. W. Daily and G. Bugliarello, Massachusetts Inst. of Tech., Cambridge, Mass.

2:00 p.m.–5:00 p.m. Tenth Session (Monongahela Room)

Engineering Economics, G. W. SARGENT, Central Fibre Products Co., Quincy, Ill., *Chairman*

6:00 p.m.–7:00 p.m. Cocktail Party (Urban Room)

7:00 p.m. Banquet (Ball Room)

Toastmaster, M. H. FISHER, Westinghouse Electric Co., East Pittsburgh, Pa.

Conference Arrangements Chairman Speaker: (to be announced later)

10:00 p.m.–1:00 a.m. Dance (Ball Room)

WEDNESDAY, OCT. 14, 1959

7:30 a.m. Chemical Engineering Author's Breakfast (Parlor B)
8:00 a.m.–12:00 Noon. Registration (Duquesne Room)
9:00 a.m.–12:00 Noon. Eleventh Session (Monongahela Room)

Corrosion, E. W. HOPPER, Pittsburgh, Pa., *Chairman*

1. "The Use of Titanium in the Pulp and Paper Industry," by W. K. Boyd, Battelle Memorial Inst., Columbus, Ohio.
2. "Corrosion of Fourdrinier Wires," by J. Gerhauser, Appleton Wire Works, Appleton, Wis.
3. "Digester Corrosion at Union Bag-Camp Paper Corp.," by H. B. Harris, Jr., and L. Parks, Union Bag-Camp Paper Corp., Savannah, Ga.
4. "Corrosion of Mild Steel in Alkaline Pulping Liquors. Final Report of Project Partially Sponsored by TAPPI Research Grant No. 86," R. B. Kesler, The Institute of Paper Chemistry, Appleton, Wis.

9:00 a.m.–12:00 Noon. Twelfth Session (Urban Room).

Industrial Engineering and Materials Handling, by B. C. KENDALL, Crown-Zellerbach Corp., San Francisco, Calif., *Chairman*

9:00 a.m.–12:00 Noon. Thirteenth Session (Allegheny Room)

Chemical Engineering, I, Systems Engineering and Operations Research, E. F. THODE, The Institute of Paper Chemistry, Appleton, Wis., *Chairman*

1. "Process Understanding Required for Systems Engineering," by J. O. Hougen, Monsanto Chemical Co., St. Louis, Mo.
2. "Computer Control in the Pulp and Paper Industry," by T. M. Stout, Thompson-Ramo-Wooldridge Products Co., Los Angeles, Calif.
3. "Analog Simulation of a Complex Level Control System," by K. Humme, Kimberly-Clark Corp., Neenah, Wis.
4. "The Application of a Unique Analog Computer to Product Distribution," by C. E. McCarty, Scott Paper Co., Chester, Pa.

12:30 p.m. Engineering Division Luncheon (Ball Room)

J. R. CURTIS, Scott Paper Co., Chester, Pa., *Division Chairman*

Speaker: (to be announced later)

2:00 p.m.–5:00 p.m. Fourteenth Session (Urban Room)

Chemical Engineering, II, A. W. PLUMMER, Hudson Pulp and Paper Co., So. Windham, Me., *Chairman*

1. "Unusual Start-up Procedures for New Kraft Mill," by F. A. Knight, Standard Packaging Corp., Eastern Div., Bangor, Me.
2. "Wetting Agent Influence on Water in Sheets after Free Drainage," by R. V. Touchette, International Paper Co., Ticonderoga, N. Y., and L. C. Jenness, University of Maine, Orono, Me.
3. "Operation of Continuous Cold Caustic Pulping Systems," by J. Dyer, Bowaters Southern Paper Corp., Calhoun, Tenn.
4. "Thermodynamic Properties of the System Na_2SO_3-$NaHSO_3$," by R. S. Morgan, Mohawk Paper Mills, Inc., Conoes, N. Y.

2:00 p.m.–5:00 p.m. Fifteenth Session (Monongahela Room)

Drying, S. G. HOLT, Consolidated Water Power and Paper Co., Wisconsin Rapids, Wis., *Chairman*

2:00 p.m.–5:00 p.m. Sixteenth Session (Allegheny Room)

Corrosion, II, E. W. HOPPER, Pittsburgh, Pa., *Chairman*

"Overlay Repair of Alkaline Pulping Digesters"
Moderator: E. W. Hopper
Panel: Z. Blanchard, Portland Co., Portland, Me.; H. M. Canavan, Mutual Boiler and Machinery Ins. Co., Waltham, Mass.; E. G. Holmberg, International Nickel Co., Inc., New York, N. Y.; D. Innes, International Paper Co., So. Kraft Division, Mobile, Ala.; W. H. Parker, Hartford Steam Boiler and Ins. Co., Hartford, Conn.; P. Zouck, Alloy Cladding Co., Baltimore, Md.

4:30 p.m.–5:30 p.m. Engineering Data Committee (Park View Room)

6:00 p.m.–8:00 p.m. Division Staff Dinner (Grant Room)

THURSDAY, OCT. 15, 1959

9:15 a.m. Mill Tour A—Jessop Steel Co., Washington, Pa.; National Annealing Box, Washington, Pa.

9:15 a.m. Mill Tour B—Atomic Research Lab., Waltz Mills, Pa.. Westinghouse Research Lab., Pittsburgh, Pa.

Ladies Headquarters—Sunday—Thursday Room 1690

Conference Headquarters—Sunday—Friday Parlor G

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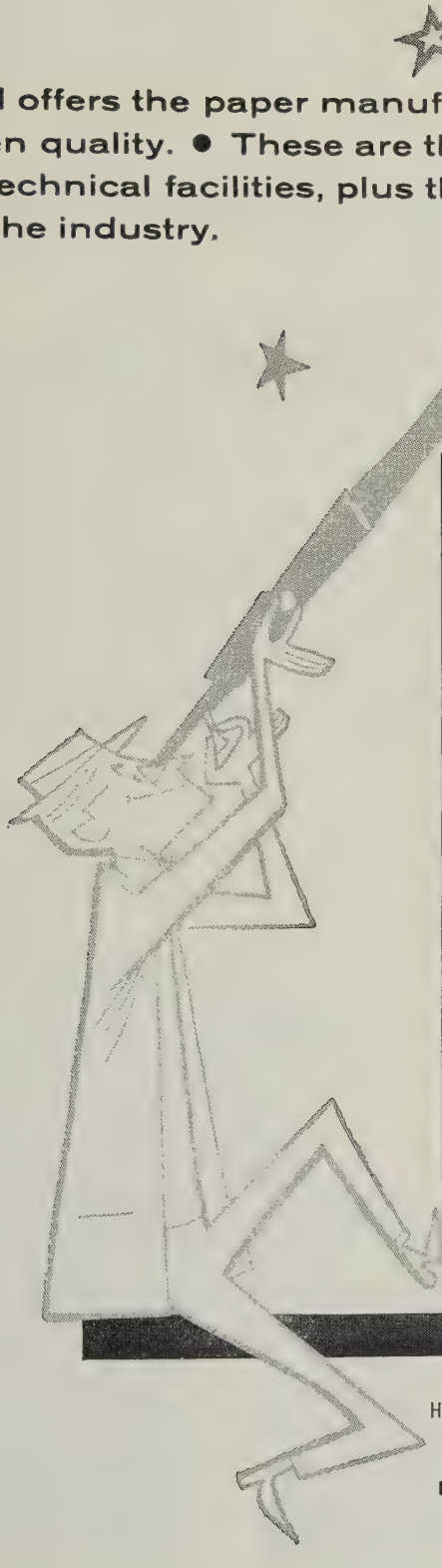

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Room Assignments—Condensed Schedule as of May 12, 1959

Room	Oct. 11 Sunday (1) a.m.	Oct. 11 Sunday (2) Noon	Oct. 11 Sunday (3) p.m.	Oct. 12 Monday (1) a.m.	Oct. 12 Monday (2) Noon	Oct. 12 Monday (3) p.m.	Oct. 13 Tuesday (1) a.m.	Oct. 13 Tuesday (2) Noon	Oct. 13 Tuesday (3) p.m.	Oct. 14 Wednesday (1) a.m.	Oct. 14 Wednesday (2) Noon	Oct. 14 Wednesday (3) p.m.
					Not Available							
Ball Room									[c]		X	
Urban				X		X	X		[b]	X		X
Monongahela				X		X	X		X	X		X
Allegheny							X			X		X
Ft. Duquesne			[a]	X	X	X	X	X	X	X	X	
Parlor G*		X	X	X	X	X	X	X	X	X	X	X
Parlor B	[g]	[b]				[j]				[k]		
Club					X							
Sky					X			X				
Park View					X			X				[d]
Grant					X			X				[e]
Room 566					X			X				
Room 766					X			X				
Aero								X				
Room 1690			[f]	X	X	X	X	X	X	X	X	X

[a] 4 to 8 p.m. [b] Also 6 to 7 p.m. [c] 7 p.m. to 1 a.m. [d] 4:30 to 5:30 p.m. [e] 6 to 8 p.m. [f] Ladies HQ through Thursday. * Conference HQ, Sunday through Friday. [g] 10 a.m. to 12 Noon. [h] 1 to 5 p.m. [i] Left unassigned for luncheon setup. (1) 9 a.m. to 12 Noon (2) 12:30 to 1:45 p.m. (3) 2 to 5 p.m. unless otherwise specified. [j] 6 p.m. [k] 7:30 a.m.

Errata

In the paper "Strength Characteristics of Bleached Sulphate and NSSC Pulps" by K. G. Chesley, appearing in the February, 1959, issue of *Tappi*, the author wishes to call attention to an error in the data presented in one of the tables.

The data in Table IV, page 135, under the column heading "apparent sp. gr.," should be corrected by multiplying each item by a factor of 0.652.

Corrugated Containers Production Committee

R. W. Buttery, Bathurst Containers, Ltd., Montreal, Que., Canada, is the new chairman of the Corrugated Containers Division Production Committee, according to an announcement by R. L. Jenk, Mead Containers, Chillicothe, Ohio, chairman of the division. Mr. Buttery succeeds K. Provo, Gaylord Container Div., Crown Zellerbach Corp., St. Louis, Mo.

R. W. Buttery, Bathurst Containers, Ltd.

Mr. Buttery was graduated from the University of Toronto in 1932 with a B.Sc. Electrical Eng. He worked for 2 years with Hygrade Containers in London, Ont., and in 1936 he was transferred to Kraft Containers in Hamilton. When Bathurst Power and Paper Co. Ltd. acquired Kraft Containers in 1946, Mr. Buttery was named production manager of the Hamilton plant. During 1949–54, he supervised the designing, building, and equipping of new plants and expansions. In 1954 he became manager of manufacturing, a position he held until 1957 when he became director of manufacturing.

In addition to his becoming chairman of the Production Committee, Mr. Buttery is also general conference chairman of the Tenth Corrugated Containers Conference to be held in Toronto, Oct. 10–13, 1960, in the Royal York Hotel.

Mr. Buttery is a member of TAPPI, CPPA Tech. Section, and the Professional Engineers of Ontario.

Dissolving Pulp Committee

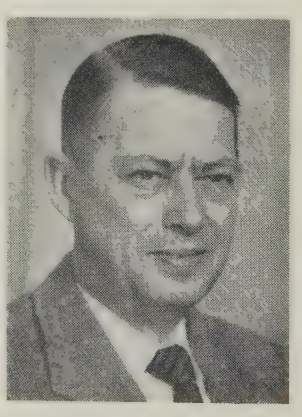
M. A. Heath, Buckeye Cellulose Corp., Memphis, Tenn., has been appointed chairman of the Dissolving Pulp Committee. He succeeds F. A. Simmonds, United States Forest Products Laboratory, Madison, Wis., who was chairman of this committee since its inception in 1952.

Mr. Heath was born in Manchester, Iowa. He received a B.A. degree in chemistry from State University of Iowa in 1927. He was graduate assistant in chemistry and did graduate work at the University of Wisconsin, earning an M.A. degree in 1931, and a Ph.D. degree, 1933. He was introduced to cellulose chemistry by Karl Paul Link, and while at Wisconsin, he carried out alkaline pulping investigations at Forest Products Laboratory, U. S. Department of Agriculture. Mr. Heath has been connected with cellulose chemistry ever since. He was chemist at Nekoosa-Edwards Paper Co., Port Edwards, Wis., during 1933 and 1934, and research chemist as well as group supervisor at E. I. du Pont de Nemours and Co., Cellulose Acetate Plant, Waynesboro, Va., from 1934 to 1946. He became acquainted with the use of the introduction purified wood pulp as a starting material for the commercial production of cellulose acetate, which previously had been manufactured only from second-cut cotton linters.

In 1946 Mr. Heath went to The Institute of Paper Chemistry, Appleton, Wis., as assistant to the late Emil Heuser. On Mr. Heuser's retirement, he became acting head of the Cellulose Department there; teaching and carrying on research in cellulose chemistry.

Since 1950 Mr. Heath has been with the Buckeye Cellulose Corp. and is concerned with their expansion into the dissolving grade wood pulp field. He has been active in process development, product research, and technical service in connection with chemical uses of cellulose.

E. J. Howard, Industrial Cellulose Research, Ltd., Hawkesbury, Ont., is the new vice-chairman of the Dissolving Pulp Committee. He succeeds M. A. Heath, Buckeye Cellulose



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E. J. Howard, Industrial Cellulose Research, Ltd.

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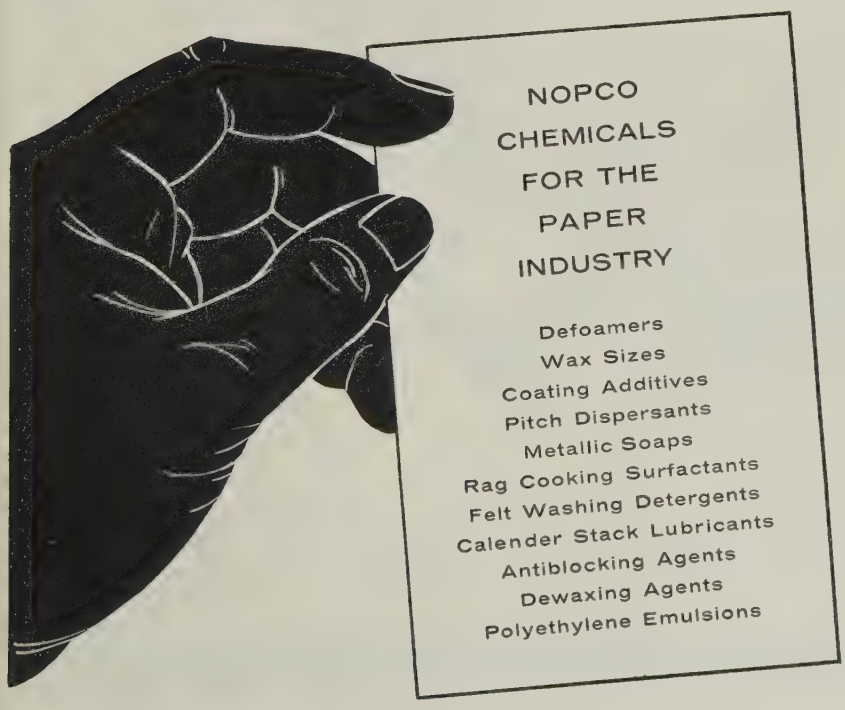

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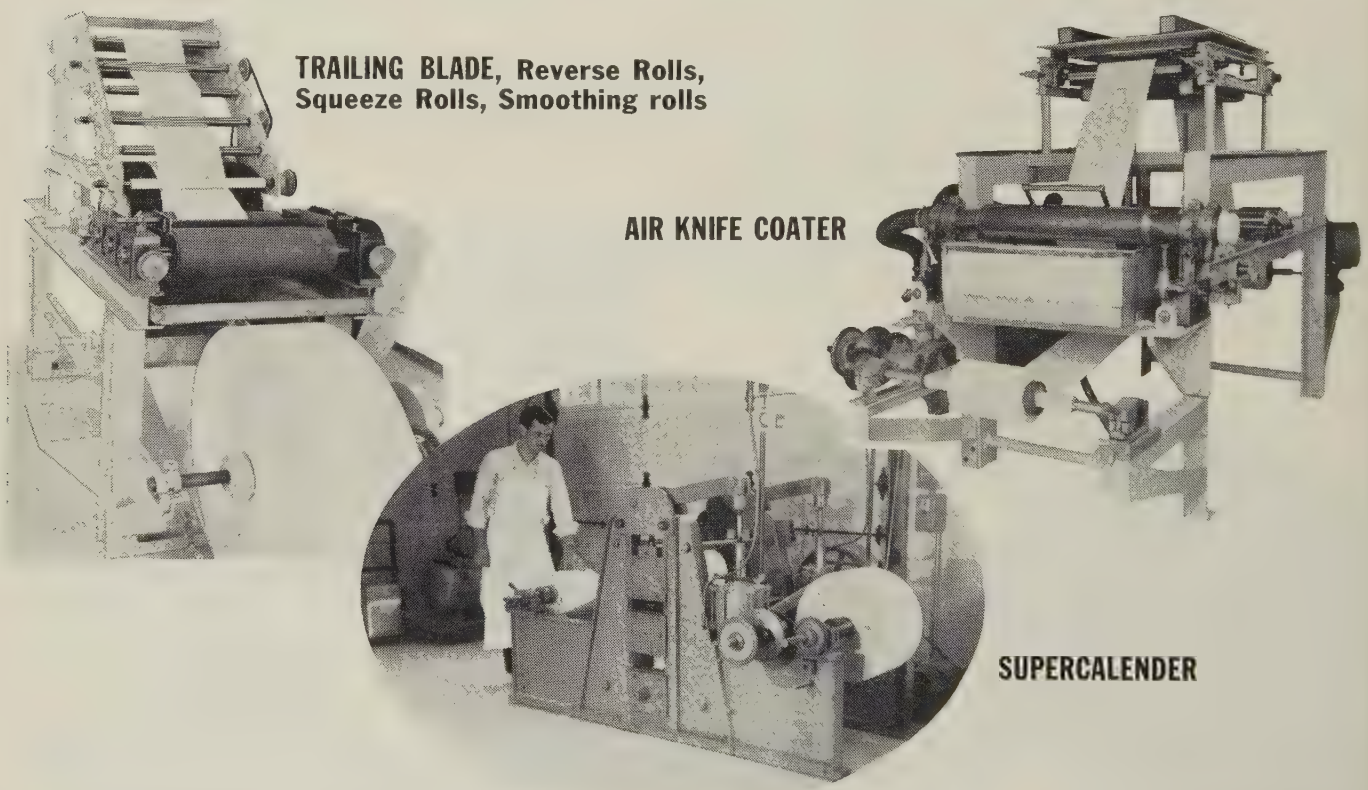

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Corp., Memphis, Tenn., who has been appointed chairman of the committee.

Mr. Howard was born in England in 1903. He studied under Prof. Partington at London University and graduated in 1925. After two years of postgraduate research in physical chemistry, he received a M.Sc. in 1927. From 1926 to 1930, Mr. Howard was a chemist in a soda pulp mill at Regensburg, Germany. This mill was based on the Rinman process (alkaline pyrolysis of spent cooking liquor to obtain ketone/methanol by-products). In 1931 he joined the Canadian International Paper Co. as mill chemist at their Kipawa Mill and 2 years later joined the research department of C.I.P. Co. at Hawkesbury, now known as Industrial Cellulose Research Limited.

His published papers are:

1. "The Influence of Dissolved Salts on the Mutual Miscibility Temperature of the Systems Ethyl Alcohol—or Menthyl Alcohol-Paraffins," *J. Chem. Soc.* p. 2787–91, 1926.
2. "Miscibility Tests of Dilute Solutions of Chromic Chloride Hexahydrates," *J. Chem. Soc.* p. 2791–2796, 1926.
3. "Sulphur Reactions in Sulphite Cooking II: Some Physico-Chemical Aspects," *Pulp & Paper Mag. Canada* 52, No. 8: 91–97 (July, 1951).
4. "Expanding the Horizon of Wood Carbohydrates," *Pulp & Paper Mag. Canada* 54, No. 5: 116–120 (April, 1953).

Mr. Howard is currently director of cellulose research and pulp development for Industrial Cellulose Research Ltd. where he is doing research on the cooking and bleaching of dissolving pulps.

Mr. Howard is a member of TAPPI, CPPA Tech. Section, Textile Res. Inst., F.C.I.C., A.A.A.S., and A.I.M.

Drying Committee

G. E. Jackson, Bowaters Carolina Corp., Catawba, S. C., has been appointed vice-chairman of the Drying Committee, according to an announcement by J. R. Curtis, Scott Paper Co., Chester, Pa., chairman of the Engineering Division.

G. E. Jackson, Bowaters Carolina Corp.

Mr. Jackson graduated from McGill University in 1943 with a Chemical Engineering degree. After graduation he worked for Anglo Canadian Pulp and Paper Mills Ltd., Quebec, in the Technical Department. He also worked for Gaspesia Sulphite Co., Ltd. at Chandler, Que., in production supervision work. Mr. Jackson was assistant sulphate superintendent at Bowaters Southern Paper Corp., Calhoun, Tenn., prior to becoming pulp mill superintendent at Bowaters Carolina Corp. at Catawba, S. C.

Agricultural Fibers Committee

The 1958 fall meeting of the Agricultural Fibers Committee was held October 15–16 when approximately 35 representatives of the strawboard mills, equipment manufacturers, suppliers, and research institutions gathered at the Peck-Fort Hayes Hotel, Columbus, Ohio, to discuss many problems of mutual interest. The meeting was essentially trifunctional: one portion being concerned with progress reports of various task committees; the second being a round-table discussion of mill operational problems and experiences; and the third being an inspection of facilities and operations of the Gaylord Container Corp. at Dresden and Baltimore, Ohio. F. B. Grunwald (Consolidated Paper) was chairman.

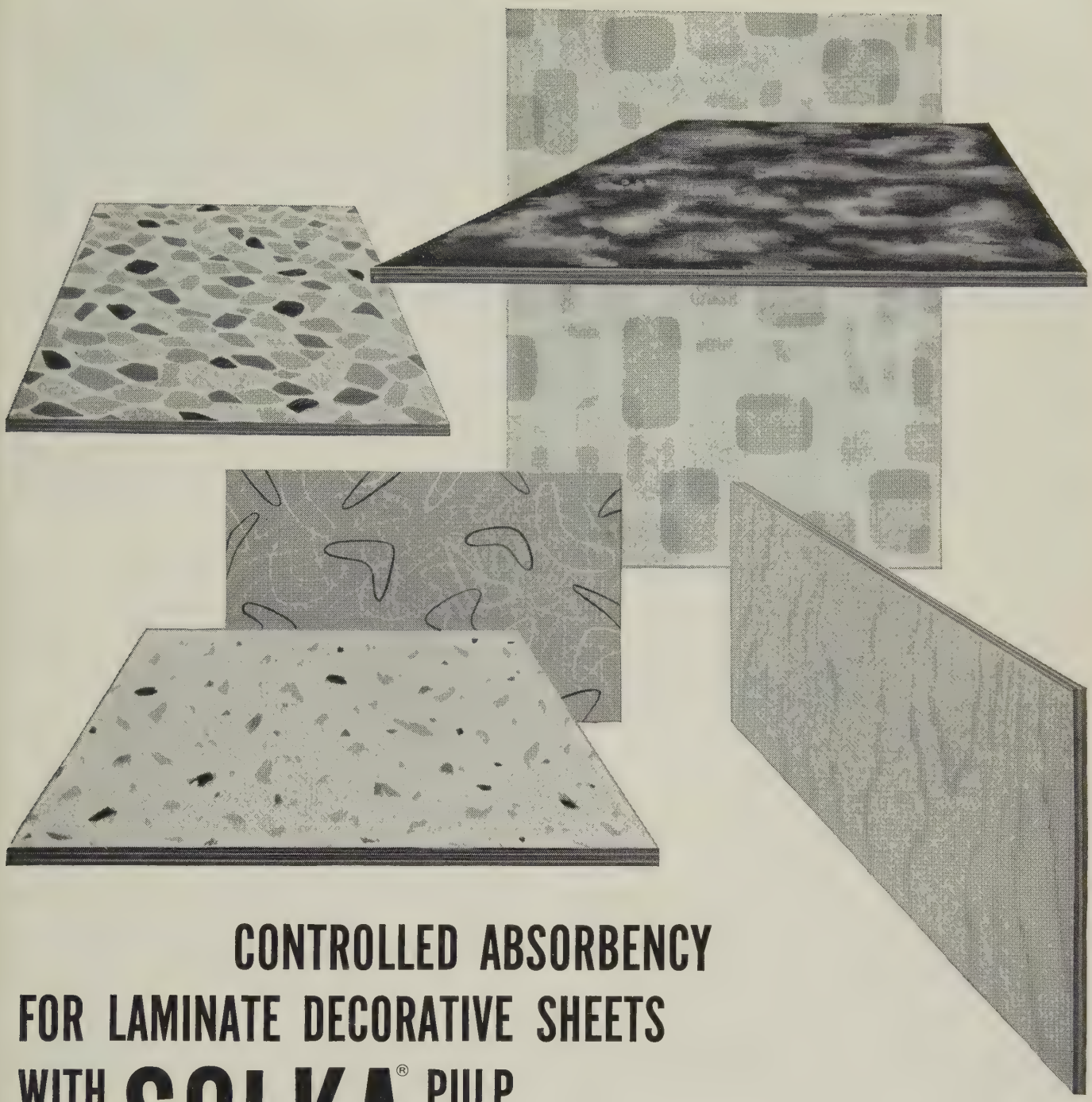
Following the introduction of Messrs. W. C. Witham and W. K. Trotter to the group by T. F. Clark, Mr. Witham explained the goals of his office (industrial liaison) and that of the Agricultural Marketing Service in trying to promote expanded use of wheat straw in pulp and paper products.

As part of the task committee report on Fundamentals of Straw Pulping, T. F. Clark, Fibrous Products Investigations, Northern Utilization Research and Development Division, Peoria, Ill., described results of initial studies by that group in pulping wheat straw by cold caustic steeping. Techniques were selected to make use of equipment already available to the strawboard mills. According to Mr. Clark, the present rotary digesters at the mills might be used for steeping on a commercial scale; in some instances auxiliary equipment for dewatering steeped straw might be required. On the basis of burst and Concora crush values, 3-hr. steeping was as effective as 5-hr. periods providing the caustic concentration was 12 to 14% based on straw. Pulp yields were about 75% while CMT values for 9-pt. board prepared on a laboratory machine were up to 91. Pulps prepared by dewatering steeped straw in a cane mill had physical characteristics better than those that had not been dewatered. High crush values, 90 to 98 CMT, were obtained when steeping involved an initial 5 min. of vacuum as part of a 1-hr. steeping cycle. Variations of vacuum and pressure during the steeping caused no further improvement. Studies on reuse of steep liquors have not progressed sufficiently to determine practicality of using refortified steep liquors. These studies are being continued.

"Continuous Pulping of Straw" was introduced by the task committee chairman, C. J. Wynstra (Central Fibre Products), who gave a brief résumé of the interest and activity within the Agricultural Fibers Committee that led to initiation of a study by the Northern Division. Mr. Wynstra explained that this study was being made with the cooperation of some of the strawboard mills. J. E. Atchison (Parsons and Whittemore) described the Pandia continuous pulping installation at Berlin, N. H., and some of the changes that had to be made to facilitate satisfactory pulping of wheat straw on a pilot-plant scale. T. F. Clark (Northern Division) then presented and discussed data pertaining to the preliminary continuous pulping operations in the pilot plant at Berlin. Thirty-one combinations of the pulping variables were investigated. Subsequent characterization and evaluation of the pulps at the Northern Division indicated the operational problems discussed by Mr. Atchison. Additional preliminary runs are contemplated before conditions are selected for semicommercial-scale pulping tests and conversion of pulps to 9-pt. board.

Chairman F. B. Grunwald (Consolidated Paper) reported for the task committee on straw preservation. He stated that from the standpoint of maximum preservation, it would be desirable to store baled straw under roof but this is not economically feasible. Recent attempts to use plastic sheeting as covering for straw ricks were unsuccessful mainly because of wind and the ease with which the sheeting tears. The earlier practice of treating ricks with borascu (borax ore) has been discontinued. Mr. Grunwald felt that this chemical treatment was too expensive for the benefits realized. He felt that no truly satisfactory method for straw preservation had been developed, and that there was need for further study in this area. Deterioration of straw has been particularly serious this season because of wet weather during the harvest period.

Machine correlation studies being conducted at the Northern Division were reported by T. F. Clark. These studies involved the relationships of quality characteristics (e.g., burst strength, resistance to crush, etc.) in 9-pt. straw corrugating boards produced on various mill machines to those of boards produced from the same furnishes on a 10-in. laboratory fourdrinier machine at the Northern Division. The precision of reproducibility of characteristics for laboratory machine



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operation is being evaluated statistically for a single straw pulp refined to various levels of freeness before being run on the machine.

H. O. Teeple (TAPPI) spoke to the group on the desirability of adequate publicity for the programs of the Agricultural Fibers Committee. To make this possible, he offered the assistance of the TAPPI headquarters in arranging programs, publicity, special facilities, etc. He suggested that the Agricultural Fibers Committee give some thought to meetings or programs that might be integrated with those of other groups such as the Corrugated Containers Division, the Alkaline Pulping Committee, and the Engineering Division. Such participation could contribute to a strengthening of the Agricultural Fibers Committee. He also pointed out the opportunities and benefits of presenting technical papers before the larger groups.

John P. Anderson, superintendent, Stone Container Corp., Coshocton, Ohio, described the company's experience with the plant which it recently changed from a strawboard mill to a corrugating plant based on a cold soda hardwood operation. The pulpwoods consist of 20% each of poplar, soft maple, and willow, and 40% of a mixture of oaks, hard maple, elm, and sassafras. Several detailed accounts of plant operations have now been published elsewhere and will not be given here. Mr. Anderson stated that power requirements for refining the wood pulp was about 17 to 19 hp. per ton in contrast to 13 to 15 hp. per ton for straw pulps. At this point R. W. Hohman (Bolton-Emerson) stated that in all conversions from straw to wood, mills had had to install additional refining facilities to handle the wood pulps.

Round-table Discussions on Operational Problems

Straw availability and preservation, chemical additives for board pulps, and quality control of pulps and boards in the mill received major attention in these discussions.

Wet weather during the straw harvest and in subsequent periods of straw storage was responsible for both reduced quality and quantity of straw for pulping in most areas. Reports indicated that bale weights ranged from 70 to 400 lb. evidence of the amount of moisture present in the bales. One Illinois mill had procured wheat straw from Nebraska at a cost of $36 per ton. Other mills reported obtaining straw from Canada at a similar expense. Users of the Canadian straw considered it superior in quality to the domestic straws. It is highly desirable that once good sound straw is procured, every reasonable effort should be made to preserve its quality. Mill operators cannot be expected to produce consistently high-quality products if the quality of the raw material is not maintained at some uniform level.

The effectiveness of chemical additives for upgrading straw pulps is still debatable. According to several of the mill operators, the results observed with several of the additives, such as gums, starch esters, and cellulose derivatives, have been quite variable. It was felt that there is a definite need for laboratory studies in order to make a quantitative appraisal of the utility of these materials. Some mills have observed that apparently favorable results have been obtained with some of the gums, but that the amount employed and their present cost do not recommend them for commercial-scale operations. One operator stated that sodium silicate had been used years ago as a beater additive, but this use could not be confirmed nor the possible benefits of such use explained.

Quality control in the production of 9-pt. corrugating board appears to be an objective that all mill operators would like to achieve. Several stated that the customary tests for pulp characterization did not seem to aid in control of or improvement of board quality. As each individual test procedure failed to provide operational control over pulp quality, the test was dropped from routine operation of the mill. While many individuals consider that freeness tests provide means for characterizing pulp drainage, most operators believe that flow and drainage properties of pulps can be evaluated only through their behavior at the mold box on the machine. Thus, the opportunity to characterize a given pulp is only minutes away from the time it becomes 9-pt. board. At this stage it is too late to modify or improve the pulp properties.

Several mills reported damage to felts in the papermaking machines because of high pH values of furnishes. One representative of the felt manufacturers stated that the most effective safeguard is to use a felt-nylon blend. A nylon content of 25% with a special factory treatment is assurance of a lifetime of service if the pH is kept below 9.0.

Bylaws were amended at this time for the period extending to the fall of 1959 to permit the present chairman to succeed himself in office. This was necessitated by the resignation of the previous vice-chairman from the normal succession. Officers for 1959 are:

Fritz B. Grunwald, chairman
A. D. Meighen, vice-chairman
T. F. Clark, secretary-treasurer

October 16 was spent in tours of Gaylord Container Corp.'s facilities at Dresden and Baltimore, Ohio. Much interest was displayed in the advanced procedure for chopping and handling straw before digestions, and for refining pulps with pump-through equipment.

Following the social hour and dinner at the Columbus University Club sponsored by Gaylord Container Corp., on October 15. Danny Galbreath, a Columbus banker, related his experiences in the frozen wastes of Alaska and the Bering Straits in hunting polar bears, caribou, and timber wolves. The thrills of flying small airplanes and the many hazards were well illustrated by the reels of color film that put the audience "on location" at Kotzebue and the Chukchi Sea.

T. F. Clark, *Secretary-Treasurer*

Attendance at TAPPI Agricultural Fibers Committee Meeting
Oct. 15–16, 1958

Name	*Company or organization*	*Address*
Anderson, Jack	Stone Container Corp.	Coshocton, Ohio
Atchison, J. E.	Parsons and Whittemore	New York City
Barber, Adrian	Shuler and Benninghofen	Hamilton, Ohio
Bisse, Paul	Gaylord Container Corp.	Baltimore, Ohio
Clark, T. F.	Northern Reg. Res. Lab.	Peoria, Ill.
Cross, Ray H.	Black-Clawson Co.	Hamilton, Ohio
Custer, H. L.	Gaylord Container Corp.	Baltimore, Ohio
Daly, Jerry	Black-Clawson Co.	Middletown, Ohio
Dow, John	Shartle Bros., Division of Black-Clawson Co.	Middletown, Ohio
Duvall, Frank C.	Black-Clawson Co.	Hamilton, Ohio
Eldridge, R. A.	Weston Paper and Mfg. Co.	Terre Haute, Ind.
Gregory, R. D.	Albany Felt	Albany, N. Y.
Grunswald, F. B.	Consolidated Paper Co.	Monroe, Mich.
Hohman, R. W.	Bolton-Emerson	Lawrence, Mass.
Lajiness, R.	Consolidated Paper Co.	Monroe, Mich.
McFarlane, R. S.	Orr Felt Co.	Piqua, Ohio
McGee, Karl	Gaylord Container Corp.	Dresden, Ohio
Meighen, A. D.	Weston Paper and Mfg. Co.	Terre Haute, Ind.
Moseman, Everett C.	Weston Paper and Mfg. Co.	Terre Haute, Ind.
Noland, Harry	Consolidated Paper Co.	Monroe, Mich.
Nooe, Eugene E.	Central Fibre Products	Quincy, Ill.
Plow, R. A.	O. A. Reynolds	Lebanon, Ind.
Prince, Ralph N.	Huyck Felt Co.	Miamisburg, Ohio
Rubeck, M. H.	Albany Felt Co.	Albany, N. Y.
Sternby, Art	Black-Clawson Co.	Middletown, Ohio
Stinson, J. C.	Gaylord Container Corp.	Baltimore, Ohio
Teeple, H. O.	TAPPI	New York, N. Y.
Trotter, W. K.	Northern Reg. Res. Lab.	Peoria, Ill.
Van Buren, C. E.	Albany Felt	Albany, N. Y.
Wallace, V. W.	Gaylord Container Corp.	Dresden, Ohio
Witham, W. C.	Northern Reg. Res. Lab.	Peoria, Ill.
Wynstra, Carl	Central Fibre Products Co.	Quincy, Ill.

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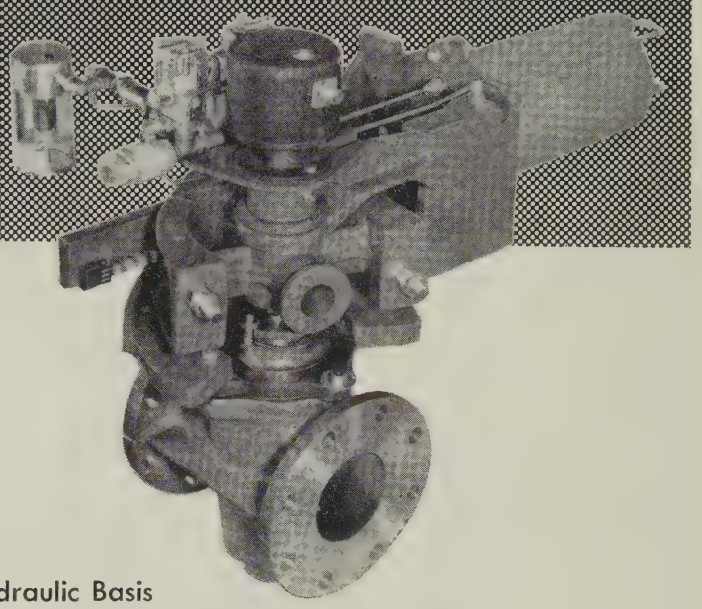

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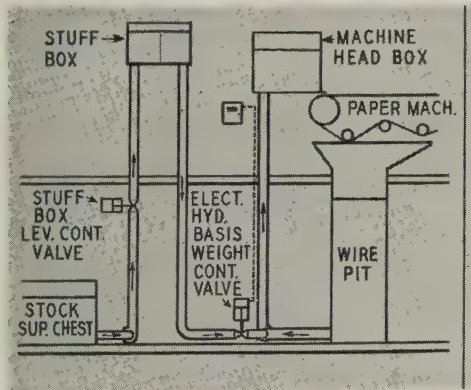

The Electric-Hydraulic Actuator, mounted on a DeZurik Vee Port Throttling Valve, will provide far greater accuracy and repeatability than can be obtained with a stuff gate mounted on the stuff box.

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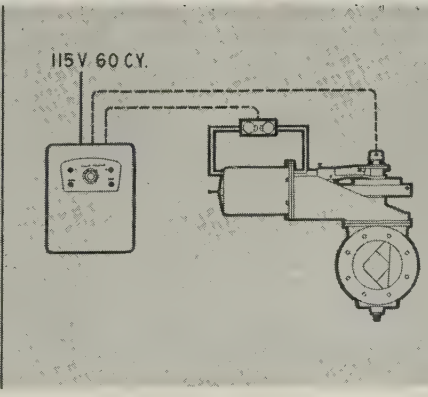
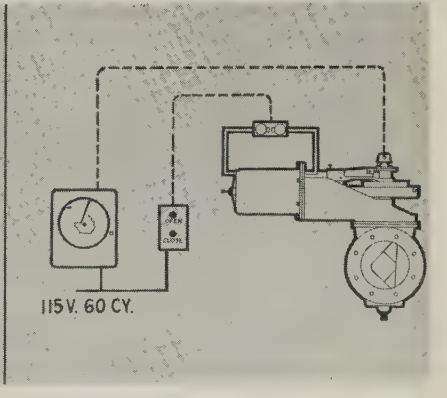


A manual control station can be furnished to provide very accurate control of the valve at an economical price. It is equipped with a vernier ten-turn counter-dial with 1000 divisions.

Since it can be set to ½ a division, this allows 2000 repeatable valve positions.



A push button station can also be used in conjunction with an electronic recording instrument. Because valve position is a function of basis weight, changes in basis weight are therefore recorded on the chart.

The output from a Beta Gage can also be used to control the valve through suitable instruments.

PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Charles Aaron, Assistant Chief Engineer, Cameron Machine Co., Dover, N. J., a 1937 graduate of New York School of Technology.

Fred C. Aldred, Research Chemist, Courtaulds Ltd., Coventry, England, a 1942 graduate of Manchester College.

Per Olof Andersson, Assistant Research Director, Swedish Forest Products Research Laboratory, Stockholm, Sweden, a graduate of Royal Institute of Technology with a Doctor of Technology degree.

Kenneth A. Arata, Manager, Process Engineering, Formica Corp., Cincinnati, Ohio, a 1932 graduate of the University of Cincinnati.

Burton P. Bailey, Chemical Engineer, The Mead Corp., Chillicothe, Ohio, a 1950 graduate of University of Cincinnati.

Eskil Beckman, Managing Director, Industria Osakeyhtio, Helsingfors, Finland, a 1917 graduate of the University of Helsingfors.

L. Chaves Belaunde, Assistant to Paper Mill Production Superintendent, Sociedad Agricola Paramonga Ltda., Paramonga, Peru, a 1949 graduate of San Marcos University.

Edward Berkyto, Mill Manager, Price Brothers & Co., Ltd., Riverbend, Que., Canada, a 1948 graduate of Queen's University.

Sergio A. Carrera, Production Control and Chemical Laboratory Dept. Superintendent, Corriere della Sera, Milan, Italy, a 1953 graduate of Politecnico di Torino.

John C. David, Research Chemist, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., a 1951 graduate of Princeton University, with a Ph.D. degree from the University of Nebraska in 1958.

James B. Dore, Laboratory Manager, Ralston Purina Co., Louisville, Ky., a 1947 graduate of Bradley University.

Harold R. Douglas, Group Leader, Howard Smith Paper Mills Ltd., Cornwall, Ont., Canada, a 1947 graduate of Queen's University.

Eloise Q. Ebert, Librarian, Oregon State Library, Salem, Ore.

Birger Eriksson, Chief Engineer, W. Rosenlew & Co., A.B., Pori, Finland, a 1950 graduate of Institute of Technology, Helsinki.

Patrick A. Florio, Head, New Products Div., Personal Products Inc., Milltown, N. J., a 1945 graduate of Columbia University with a Ph.D. degree in 1951.

Frank H. Foxlee, New Product Engineer, Union Carbide Plastics Co., New York, N. Y., a 1946 graduate of McGill University with a Ph.D. degree.

Harry R. Gamrath, Assistant Director of Research, Monsanto Chemical Co., St. Louis, Mo., a 1934 graduate of the University of Michigan with a Ph.D. degree.

Isaiah Gellman, West Coast Regional Engineer, National Council for Stream Improvement, Inc., New York, N. Y., a 1947 graduate of the College of the City of New York with a degree from Rutgers University in 1952.

Anselmo Guffanti, Consultant, Cartiera F.Lli Presenti, Nembro (Bergamo), Italy, a 1946 graduate of the Politecnico di Milano.

Charles E. Gero, Production Manager, Mohawk Paper Mills, Inc., Waterford, N. Y., a 1926 graduate of the University of Maine.

J. H. E. Hessels, Technical Director, N.V. Hollandsche Kunstzijde Industrie, Breda (Netherlands), Holland.

Robert M. Henderson, Sales Engineer, E. D. Jones Corp., Pittsfield, Mass., a 1948 graduate of Montana State College.

Richard W. Hickman, Chief Applications Engineer, Paper Div., Industrial Nucleonics Corp., Columbus, Ohio, a 1947 graduate of Rose Polytechnic Institute.

Earl Hillen, Jr., Sales Engineer, Babcock & Wilcox Co., Charlotte, N. C., a 1952 graduate of the University of Tennessee.

Alfred G. Hofmann, Student, North Carolina State College, Raleigh, N. C.

Bruce W. Huston, Supervisor, Engineering & Maintenance, Eastman Kodak Co., Rochester, N. Y., a 1949 graduate of Rochester Polytechnic Institute.

Ella Janson, Librarian, AB Sveriges Litografiska Tryckerier, Stockholm, Sweden.

Ogden W. Jervis, District Manager, The Green Fuel Economizer Co., Inc., Beacon, N. Y., a 1933 graduate from Georgia Institute of Technology.

R. S. Jobin, Chief Technical Executive, C. Davidson & Sons Ltd., Aberdeenshire, Scotland, a 1935 graduate of the University of Liverpool with a Ph.D. degree in 1937.

Dwight W. Johnson, Control Laboratory Supervisor, Mosinee Paper Mills Co., Mosinee, Wis.

A. Rezaul Karim, Chemical Groundwood Superintendent, Khulna Newsprint Project, Khulna, East Pakistan, a 1952 graduate of Ahsanullah Engineering College.

Ralph E. Kelly, Research Supervisor, Hercules Powder Co., Wilmington, Del., a 1951 graduate of the University of Minnesota with a Ph.D. degree.

Donald B. Killian, Assistant Director of Sales, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., a 1936 graduate of the University of Notre Dame with a Ph.D. degree.

Arlon F. King, Mill Chemist, Shawano Paper Mills, Shawano, Wis., a 1959 graduate of Western Michigan University.

Alfred E. Kingsland, Chief Chemist, C. Townsend Hook & Co., Ltd., Snodland, Kent, England. Attended Gillingham Technical College.

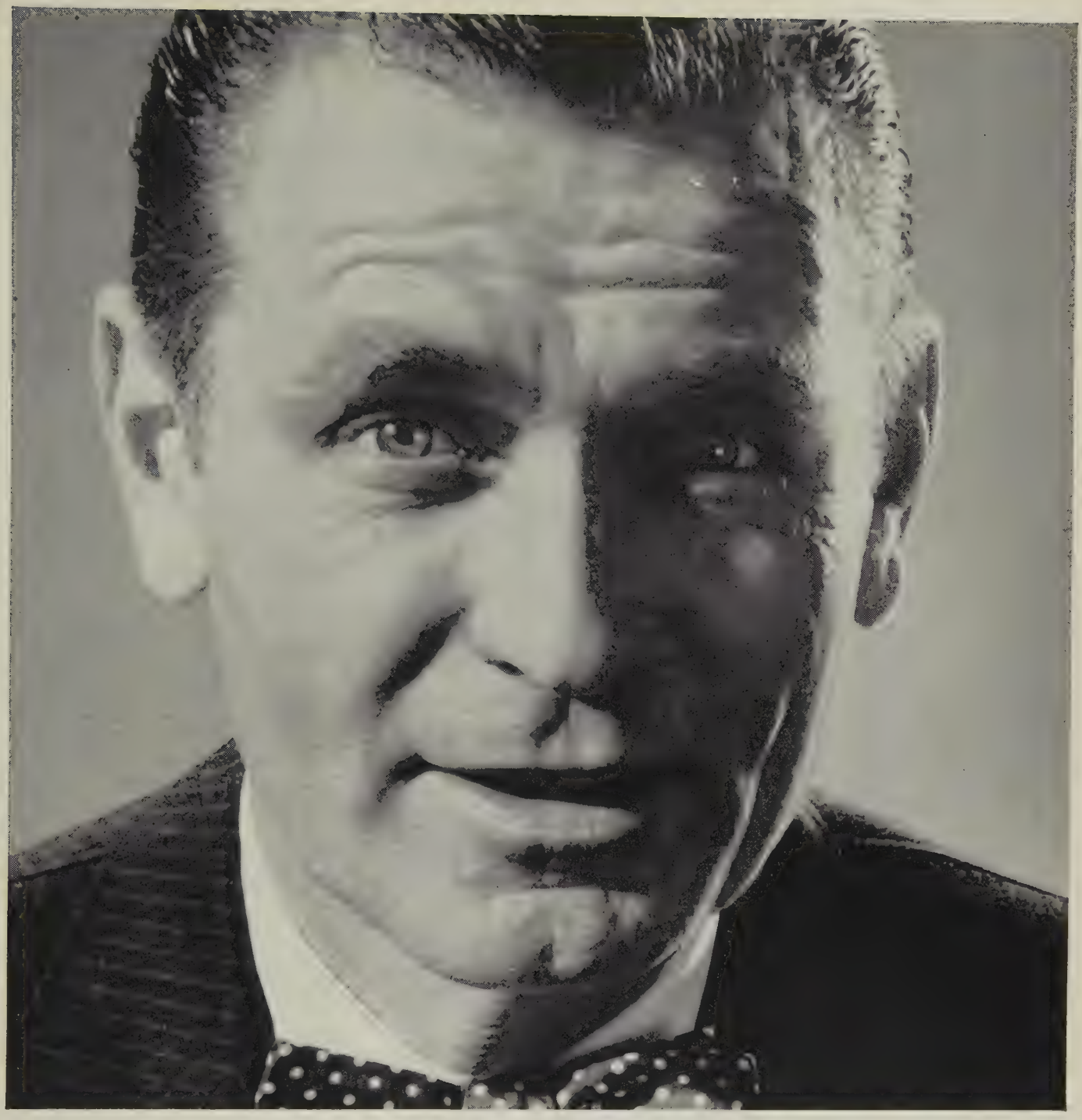
Herbert Kranich, Jr., Staff Engineer, Celite Div., Johns-Manville, New York, N. Y., a 1950 graduate of New York University.

Ray V. Lawrence, Chemist, U. S. Dept. of Agriculture, Naval Stores Research Station, Olustee, Fla., a 1933 graduate of the University of Alabama.

Yvan Lemay, Botanist, Industrial Cellulose Research Ltd., Hawkesbury, Ont., Canada, a 1956 graduate of the Université de Montreal.

Edward G. Locke, Chief, Division of Wood Chemistry, Forest Products Laboratory, Forest Service, U. S. Dept. of Agric., Madison, Wis., a 1928 graduate of Oregon State College with a Ph.D. degree from Ohio State University in 1932.

Bertil O. Lunden, Chief Engineer, Stora Kopparbergs Bergslags, A.B., Falum, Sweden, a 1936 graduate of Chalmers Technical University.



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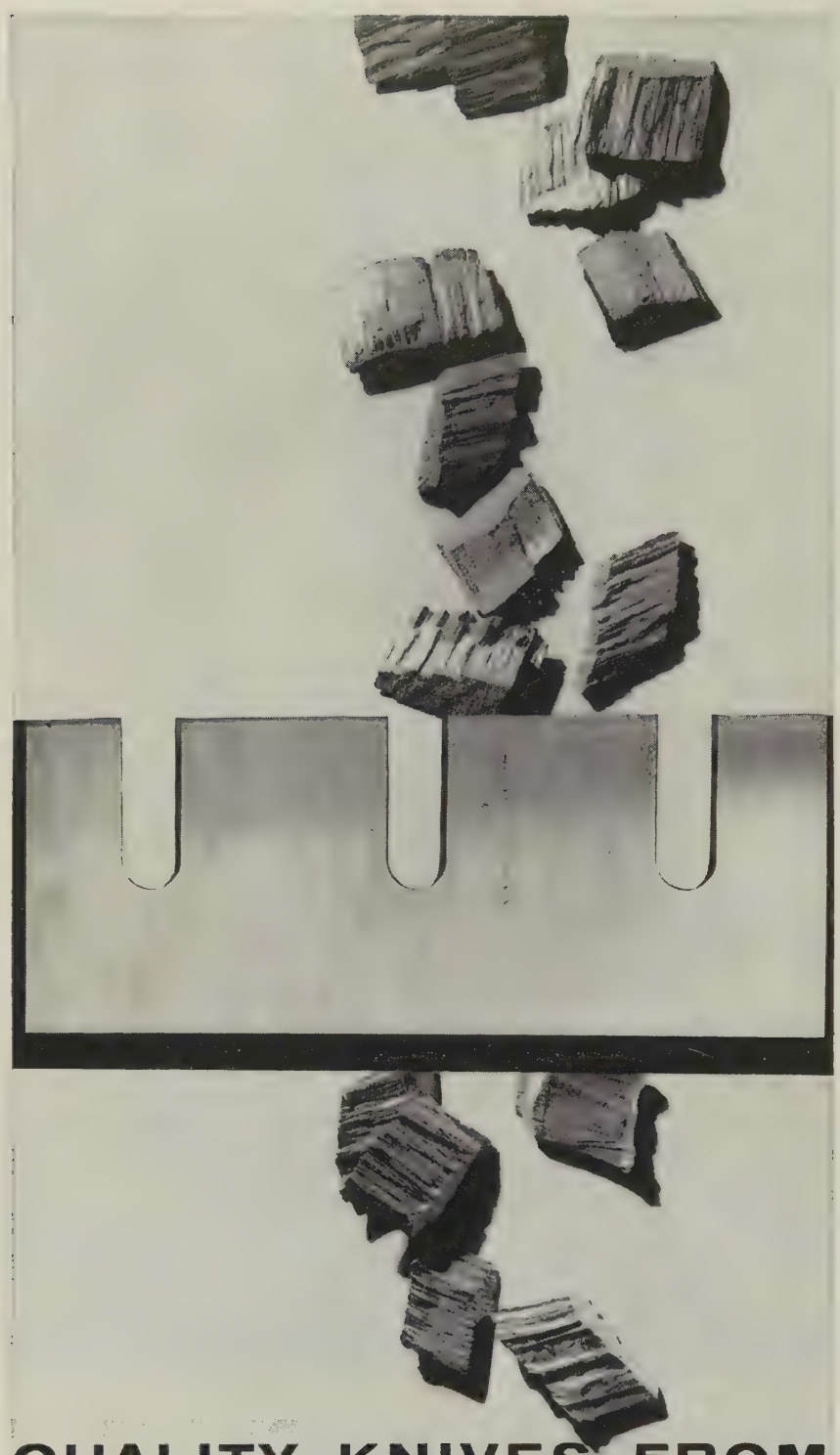

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Richard C. Mack, Assistant Production Supervisor, Eastman Kodak Co., Rochester, N. Y., a 1944 graduate of the University of Rochester.

Tamas Makray, Technical Consultant, Industria Quimica Mantiqueira, S.A., Rio de Janeiro, Brazil, a 1953 graduate of McGill University.

Joseph M. Malone, Beater Room Engineer, Merrimac Paper Co., Inc., Lawrence, Mass.

John H. McKenzie, Special Technical Assistant to Manager, Sandwell Ltd., Vancouver, B. C., Canada, a 1952 graduate of Sydney University.

Gordon McLeavy, Head of Research & Technical Service Dept., James Kenyon & Son Ltd., Bury, England, a 1944 graduate of the University of Leeds, with a Ph.D. degree in 1947.

George E. Missbach, Sales Manager-Director, Morehouse-Cowles, Inc., Los Angeles, Calif., a 1933 graduate of the University of Alabama.

William H. Mordo, Technical Service Manager, Stowe-Woodward, Inc., Newton Upper Falls, Mass. Attended Wentworth Institute.

Cariolaro Norberto, Technical Director, Cartiera Cariolaro SPA, Carmignano di Brenta (Padova), Italy.

Angelo Pagliero, Technical Manager, Cartiere Giacomo Bosso, Torino, Italy, a graduate of Torino University with a Che.D. degree.

Ned Paul, Production Manager, Bristol Paper Products Corp., Bristol, Pa.

Charles F. Payne, Assistant Superintendent Paper Mills, Eastman Kodak Co., Rochester, N. Y. Attended Massachusetts Institute of Technology.

Clifford L. Peterson, Assistant Division Engineer, Mead Corp., Kingsport, Tenn., a 1948 graduate of the University of Minnesota.

Lennart O. Pihl, Director of Research, Research AB, Virebergsvagen, Solna, Sweden, a 1947 graduate of Chalmers Technical University.

Joseph Pundyk, Project Engineer, Cameron Machine Co., Dover, N. J., a 1944 graduate of the College of the City of New York.

John E. Ray, III, Resident Manager, Union Bag-Camp Paper Corp., Franklin, Va. Attended Cornell University.

Stephen Raymond, Salesman, Arnold, Hoffman & Co., Inc., Providence, R. I., a 1948 graduate of Queen's College.

Frank A. Regan, Superintendent-Supplies, A. B. Dick Co., Chicago, Ill., a 1941 graduate of Massachusetts Institute of Technology.

J. Richard Relick, Production Manager, National Aluminate Corp., Chicago, Ill., a 1951 graduate of Dickinson College.

Cecilio G. Rueda, Foreman Engineer, Production Dept., Fabrica de Celulosa "El Pilar," S.A., Mexico D.F., Mexico.

Ralph T. Russell, Associate Director, Microbiological & Biochemical Research Center, Syracuse University, Syracuse, N. Y., a 1943 graduate of Syracuse University with a Ph.D. degree.

Ernest E. St. Louis, General Manager, Valchem Corp., Langley, S. C., a 1950 graduate of Rhode Island State College.

P. B. Sarkar, Director, Technological Research Laboratories, Indian Central Jute Committee, Calcutta, India.

William T. Schick, Manager of Sales Administration, The Black-Clawson Co., Middletown, Ohio, a 1947 graduate of New York College of Forestry.

Leon A. Schmidt, Project Engineer, Cameron Machine Co., Dover, N. J., a 1938 graduate of Columbia University.

Emil Schnitzpahn, Sales Engineer, John Waldron Corp., New Brunswick, N. J., a 1927 graduate of Pratt Institute.

Karl Sieber, Hannoversche Papierfabriken, Alfeld/Leine, West Germany, a 1952 graduate of Dresden University with a Eng.D. degree.

Richard A. Silberman, Quality Control Superintendent, St. Lawrence Paper Corp., Norfolk, N. Y., a 1948 graduate of the University of Illinois.

Billie Sutcliffe, Assistant Research Manager, Courtaulds (Canada) Ltd., Cornwall, Ont., Canada, a 1947 graduate of Christ's College.

James Teng, Research Chemist, Nylonge Corp., Cleveland, Ohio, a 1952 graduate of Princeton University.

Leon P. Tisdale, Superintendent, Hurlbut Paper Co., South Lee, Mass.

Erich W. R. Torke, Chemical Director, Friedrich Krupp Industries, Essen, West Germany, a 1928 graduate of the University of Leipzig.

Rinse Van Den Ende, Production Manager, Plant at Velsen, Koninklijke Papierfabrieken Van Gelder Zonen N.V., Amsterdam-C., Netherlands.

Albert F. Van Loosbroek, Manager, Drukkerij van Loosbroak, Oss, Holland.

William P. Weber, District Sales Manager, The Glidden Co., New York, N. Y., a 1953 graduate of Rutgers University.

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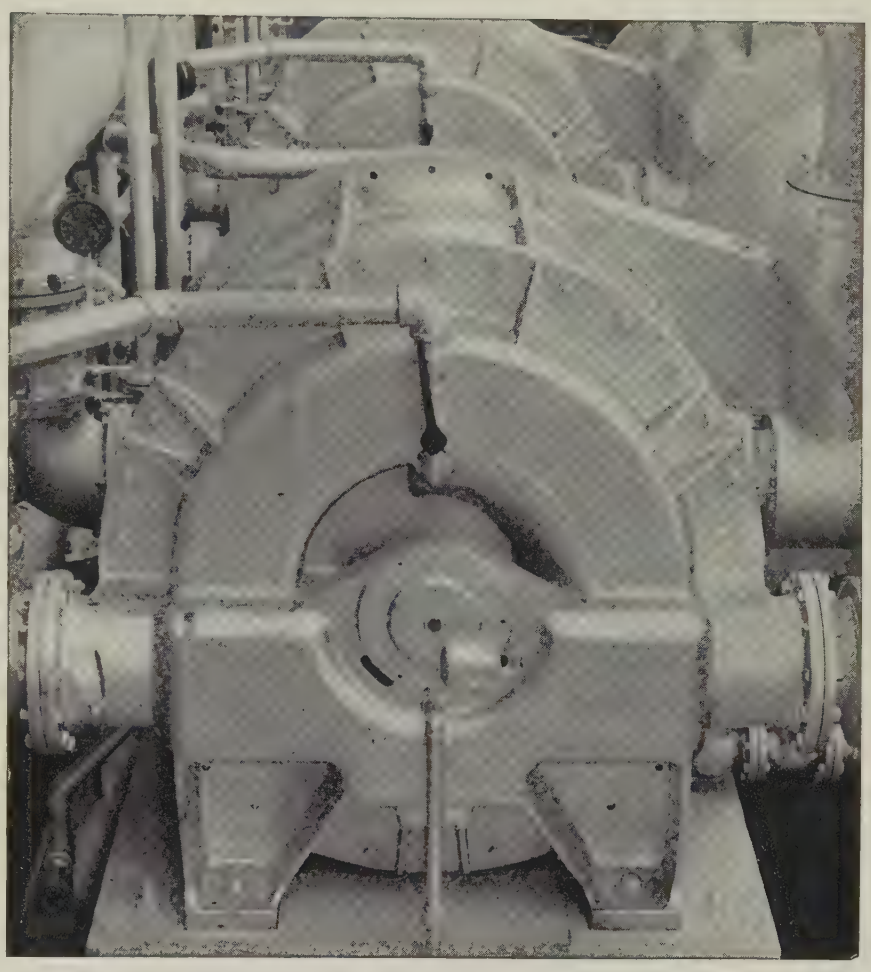

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Wilhelm Wolff, General Director, Samum Vereinigte Papier Industrie K.G., Vienna, Austria, a 1931 graduate of Technical University, Darmstadt.

Shigekazu Yamakawa, Chief of Industrial Engineering Section, Tokyo Shibaura Electric Co., Ltd., Tokyo, Japan, a 1939 graduate of Tokyo University.

Hubert P. Zhorne, Sales, National Starch & Chemical Corp., New York, N. Y., a 1951 graduate of Coe College.

Phillip M. Ziegler, Plant Engineer, Fort Wayne Corrugated Paper Co., Hartford City, Ind., a 1955 graduate of the Detroit Institute of Technology.

TAPPI Notes

William J. Andrews, formerly of the Haloid Co., is now Chemist in the Polyfibrous Division of Dewey & Almy Chemical Co., Cambridge, Mass.

John R. Arnold, formerly of the Escanaba Paper Co., is now with Lamox, Inc., Norcross, Ga.

Weston T. Bennett is now Vice-President in Charge of Engineering for the Canadian International Paper Co., Montreal, P. Q.

Ralph H. Bernstein, formerly of the New Haven Board & Carton Co., is now an Engineer with Chas. T. Main, Inc., Boston, Mass.

L. F. Bornstein, formerly of the Synvar Corp., isno w Vice-President and General Manager of National Polychemicals, Inc., Wilmington, Mass.

Henry G. Caldwell is now Assistant Director of Chemical Research for the Mead Corp., Chillicothe, Ohio.

Olin W. Callighan is now Director of Customer Relations for Minerals & Chemicals Corp., Edgar Division, Kalamazoo, Mich.

George A. Charters of the Crown Zellerbach Corp. has been transferred from Seattle, Wash., to Orange, Tex., as Superintendent of the Western Waxide Division.

C. William Converse, formerly of Black-Clawson International, is now with Lyddon & Co., Ltd., London, England.

Alan B. Copping is now Manager of the Otis mill of International Paper Co., Chisholm, Me.

Paul B. Corning is now a Project Engineer for Parsons & Whittemore, Inc., New York, N. Y.

Donald W. Curtis, formerly of the Beloit Iron Works, is now Assistant to the President of E. D. Jones Corp., Pittsfield, Mass.

John H. Doherty is now Manager of Marketing Research for the Union Bag-Camp Paper Corp., New York, N. Y.

Dan D. Downes, formerly of the Dayton Oil Co., is Assistant Sales Manager for the Distillation Products Division of the Capitol City Products Corp., Columbus, Ohio.

Edward L. Dozier is now General Manufacturing Superintendent of the Chesapeake Corp. of Virginia, West Point, Va.

Walter D. Esselstein is now Vice-President in Charge of Manufacture of Bemis-Jason Co., Redwood City, Calif.

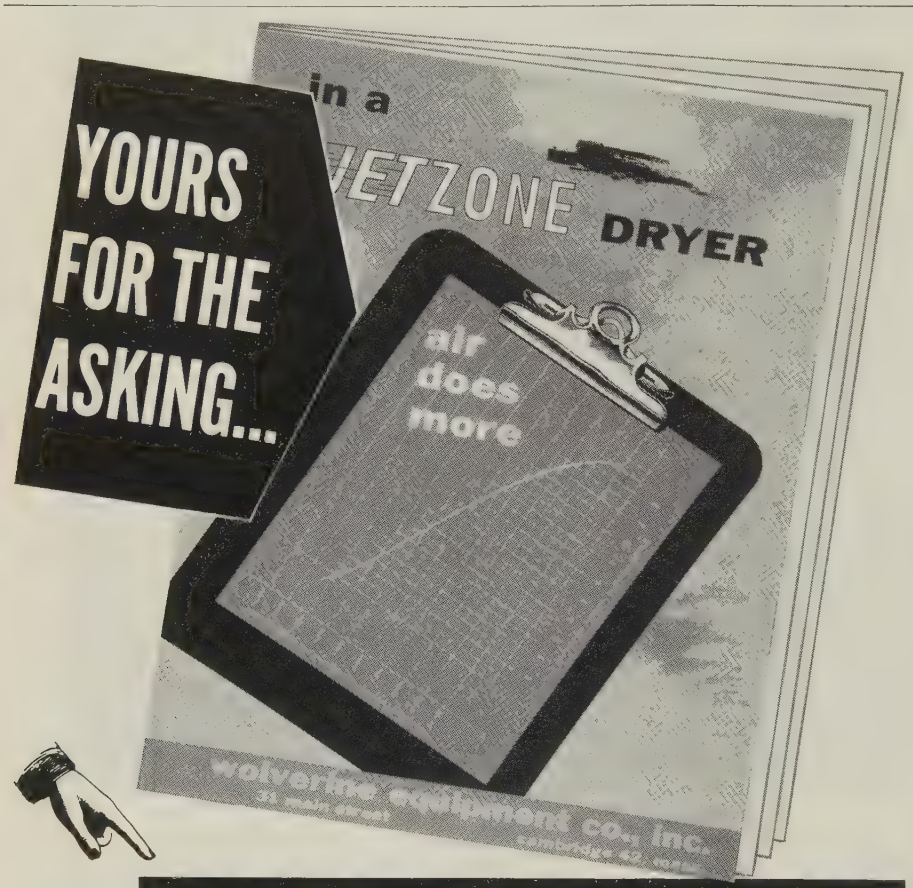
Horace B. Faber, Jr., formerly a student at The Institute of Paper Chemistry, is now a Research Associate for Eaton Dikeman Co., Mt. Holly Springs, Pa.

Rosewell P. Fallon is now Superintendent of Manufacture for the St. Regis Paper Co., Herrings, N. Y.

Fred D. Floyd of the International Paper Co. has been transferred from Bastrop, La., to Moss Point, Miss., as Assistant to the Plant Manager.

R. C. Germanson is now Supervisor of Mill Technical Service for the KVP Co., Kalamazoo, Mich.

Fred J. Giffen is now Manager of Manufacturing of the Canadian International Paper Co., Montreal, P. Q.



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Richard H. Green of the Mead Corp. has been transferred from Sylva, N. C., to Kingsport, Tenn., as a technical service man.

Martin H. Gurley, Jr., Consultant, has moved his office from Charlotte, N. C., to Lexington, Va.

Gerald A. Hale is now Manager of Paper Labs for the Minerals & Chemicals Corp. of America, Menlo Park, N. J.

David H. Hall of the B. F. Goodrich Chemical Co. has been transferred from Cleveland, Ohio, to Chicago Ill., as a Product Engineer.

William V. Hanson, formerly of the Badger Paper Mills Co., is now a staff assistant in the manufacturing department of Oxford Paper Co., New York, N. Y.

Patrick J. Hassett is now Superintendent of the kraft mill of the Nekoosa-Edwards Paper Co., Port Edwards, Wis.

John A. Haug, formerly a student at the University of New Hampshire, is now an Engineer for the Haug Development Co., Nashua, N. H.

Warner C. Holman, formerly a student at the Institute of Paper Chemistry, is now a Research Engineer for the St. Regis Paper Co., Deferiet, N. Y.

John F. Hooper of Rayonier, Inc., has been transferred from Jesup, Ga., to Port Angeles, Wash., as Assistant Resident Manager.

Carl W. Horst, formerly of American Box Board Co., is now with Fibreboard Paper Products Corp., Lafayette, Calif.

Reginald H. Hurst is now Supervisor of Customer Technical Service for the KVP Co., Kalamazoo, Mich.

John C. Hyatt, formerly of the Rhinelander Paper Co., is now with the Hamersley Paper Co., Garfield N. J.

William H. Jackson, formerly of the Babcock & Wilcox Co., is now Vice-President in Charge of Sales for the Diamond Power Specialty Co., Lancaster, Ohio.

Ake Jansson, formerly of Klippans Finpappersbruk, is now Works Manager of Cellulose Products Pty. Ltd., Johannesburg, South Africa.

Robert W. Kent of Champion Paper & Fibre Co. has been transferred from Pasadena, Tex., to Hamilton, Ohio, as Chief Maintenance Engineer.

Jerome J. Kipness is now Manager of Container Laboratories, Inc., Chicago, Ill.

Louis A. Korte, formerly of the American Dyewood Co., is now a process engineer for Sinclair & Valentine Co., Ridgway, Pa.

Howard J. Leech, formerly of the Weyerhaeuser Timber Co., is now Chief Paperboard Chemist for the North Carolina Pulp Co., Plymouth, N. C.

Gordon Lockyer, formerly of the Arvey Corp., is now with the National Dairy Products Corp., Glenview, Ill.

James C. Lowe, formerly of Alexander Lawrie Co., Ltd., is now a Director-Partner for Manderstam, Lowe Co., London, England.

Norval Magnusson is now Supervisor for the Lignin Products Dept., Puget Sound Pulp & Timber Co., Bellingham, Wash.

Frank J. McCourt of the International Paper Co. has been transferred from Palmer, N. Y., to York Haven, Pa., as Assistant Manager.

James McGovern, formerly of the American Box Board Co., is now an industrial engineer for Chippewa Paper Products Co., Chicago, Ill.

Kenneth A. McLarty of the Flintkote Co. has been transferred from Los Angeles, Calif., to Hilo, Hawaii, as Plant Engineer.

Andrew B. O'Neill, formerly of Minerals & Chemicals Corp. of America, is now with A. E. Staley Mfg. Co., Decatur, Ill.

C. Cline Peters is now Assistant Manager of Production at Riegel Paper Corp., Acme, N. C.

Arthur W. Plummer, formerly of Kimberly-Clark Corp., is now Associate Director of Research and Development for the Hudson Pulp & Paper Corp., South Windham, Me.

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I. Bruce Sanborn, formerly of the West Virginia Pulp & Paper Co., is now a student at The Institute of Paper Chemistry, Appleton, Wis.

Richard L. Savage, formerly of the Consolidated Water Power & Paper Co., is now Senior Research Chemist for the Naugatuck Chemical Division of U. S. Rubber Co., Naugatuck, Conn.

William J. Shaughnessy, formerly of the U. S. Navy, is now a service engineer for the Albany Felt Co., Albany, N. Y.

Marcel Sicard, formerly of Walter Down & Co. Ltd., is now a project engineer for the Federal Pacific Electric Co., Montreal, Canada.

John L. Sigler of John W. Bolton & Sons Inc. has been transferred from Lawrence, Mass., to Jacksonville, Fla., as Manager of the Southern Region.

Robert W. Snow, formerly of The Institute of Paper Chemistry, is now a Chemist for the Northwest Paper Co., Cloquet, Minn.

Murray Stempel is now President of Morningstar-Paisley, Inc., Chicago, Ill.

Edgar L. Stentz is now General Production Manager of the Ohio Boxboard Co., Rittman, Ohio.

Clifford R. Swett is now Vice-President of the National Wax Co., Skokie, Ill.

Lawrence G. Thurston is now Manager of the International Paper Co., Niagara Falls, N. Y.

John G. Turk, formerly of the Glass Container Manufacturers Institute, is now Technical Director of the Research, Product Development and Standards Laboratory, Paper Products Div., Owens-Illinois Glass Co., Toledo, Ohio.

Conrad T. Waldie is now Technical Assistant to the President of the Brown Co., Berlin, N. H.

William T. Webster, formerly of the National Container Corp., is now Director of the Pulp and Paper Division of H. K. Ferguson Co., Cleveland, Ohio.

James W. Winn, formerly of the Hartford City Paper Co., is now in the Research & Development Department of the Lee Paper Co., Vicksburg, Mich.

Sampson W. Yates is now Vice-President in Charge of Production for the Robertson Paper Box Co., Montville, Conn.

Minoru Yoshimura is now Technical Assistant to the Vice-President of the Alaska Lumber & Pulp Co., Sitka, Alaska.

Curt A. Young is now General Manager of Engineering for the Continental Can Co., New York, N. Y.

Robert R. Young of the Pollock Paper Division, St. Regis Paper Co., has been transferred from Columbus, Ohio, to Middletown, Ohio, as Quality Control Supervisor.

Robert S. Young is now Manager of Mill Operations for the Hammermill Paper Co., Erie, Pa.

Albert P. Yundt, formerly of the Union Bag-Camp Paper Corp., is now Owner of the Alac Co., Franklin, Va.

* * *

Louis J. Slavin, Vice-President, has succeeded *William Slavin* as the official corporate representative of the Hawthorne Paper Co., Kalamazoo, Mich., in the Technical Association.

* * *

W. M. Marcussen has succeeded *W. G. Kelly* as the official representative of the Atlantic Refining Co., Philadelphia, Pa., in TAPPI.

A. B. Adams has succeeded *H. E. Keene* as the official representative of the Goslin-Birmingham Mfg. Co., Birmingham, Ala., in TAPPI.

J. O. Logan, Executive Vice-President, has succeeded *D. W. Drummond* as the official representative of the Olin Mathieson Chemical Corp., Baltimore, Md., in the Technical Association.

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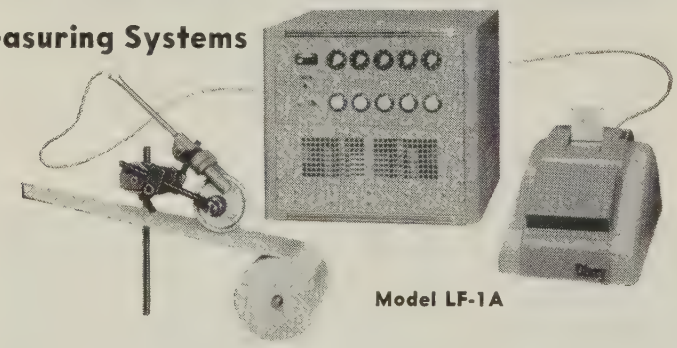

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Industry Notes

Production

Paper and board production during February amounted to 2,612,502 tons. This was 10% above the 2,370,466 tons produced in February a year ago. Paper production amounted to 1,145,574 tons, which was 8% above the 1,056,591 tons produced in February a year ago. The output of paperboard during this month was 1,221,019 tons, reflecting a 12% increase above the production of 1,089,129 tons reported for February, 1958.

Pulpwood

Pulpwood receipts at the pulp mills in February amounted to 3,005,450 cords, with consumpton at 2,958,045 cords. Month-end inventories decreased slightly to 5,970,390 cords.

Wastepaper

Consumption of fibrous materials other than pulpwood, totaled 827,797 tons in February compared to 797,408 tons in January, 1959. Inventories of 936,600 tons at month's end reflected a 4% decrease under end of January inventories. Consumption of wastepaper amounted to 745,766 tons, as compared to 663,147 tons consumed in February a year ago.

Wood Pulp

Wood pulp production during February amounted to 1,842,499 tons as compared to 1,680,872 tons produced in February a year ago.

Wood pulp consumption in the paper and board mills during February amounted to 1,912,653 tons, compared to the 1,719,704 tons consumed in February a year ago.

Wood pulp inventories at the end of February at the paper and board mills amounted to 548,960 tons, compared to 552,699 tons reported at the end of January. Month-end stocks of pulp mills were 273,028 tons as compared to 271,117 tons reported at the end of January.

Manpower

Nearly three quarters of a million scientists and engineers were employed by American industry as of January, 1957. This total included 528,000 engineers, 152,000 scientists, and 58,000 administrators of scientific and engineering activities. Almost one third of these scientists and engineers were engaged in research and development activities. The 738,000 scientists and engineers employed in the industries covered by this survey are estimated to represent approximately two thirds of all scientists and engineers in the nation.

These and other data are some of the preliminary findings from a survey of scientific manpower and of industrial research and development costs recently conducted by the United States Bureau of Labor Statistics for the National Science Foundation. The survey collected data on employment of scientists and engineers as of January, 1957 and on research and development costs for calendar year 1956.

Boy Scout Booklet

"Patrol and Troop Forestry Activities," prepared by American Forest Products Industries, Inc. is now being distributed to 75,000 troops by Boy Scouts of America as one of two items in the "Boy Scout Forestry Kit—Scoutmaster's Program Helps." The other item is a booklet supplied by the United States Forest Service.

Arthur A. Schuck, Chief Scout Executive, wrote to AFPI Jan. 8, 1959 as follows about the kit:

"There is no doubt but that this kit, when distributed to more than 70,000 scoutmasters and other key leaders, will do more than anything we have done in the past to get across to boys some of the important fundamentals of forest conservation. Your list of Scout-sized projects is so comprehensive that any troop anywhere is bound to find at least a few that can be carried out locally, to the end that boys may learn-by-doing not only the importance of our forest resources but some of the techniques used in their management.

"We value very highly the continued help and cooperation of AFPI."

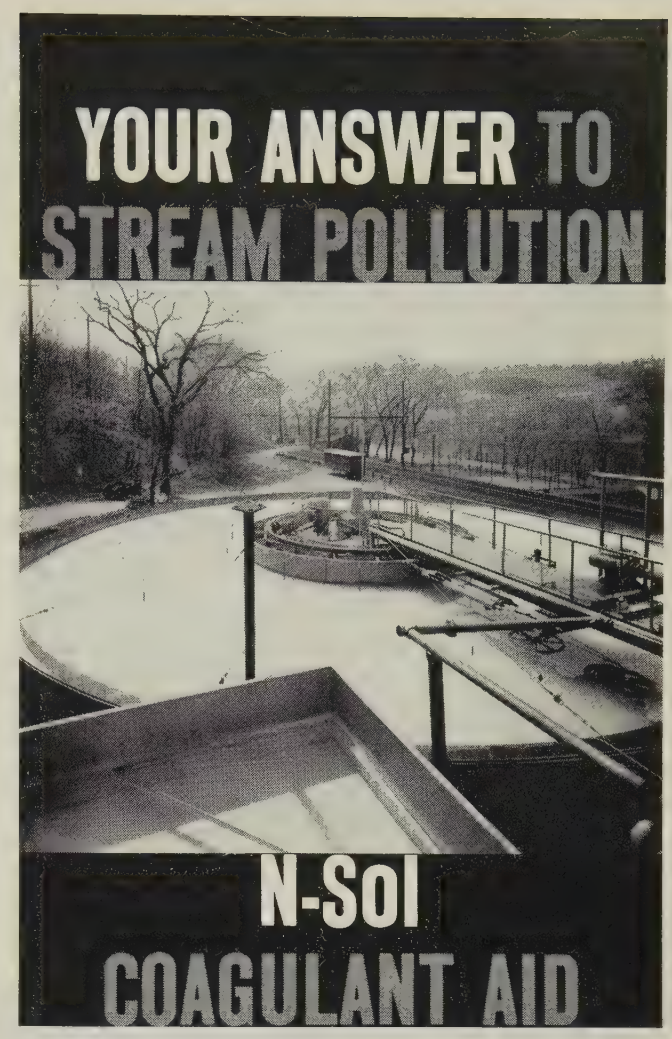
Delaware Timber Survey

One-third of the land of Delaware is forested—nearly 400,000 acres—according to a survey completed by the Unites States Forest Service in cooperation with the State Forestry Department of Delaware.

These survey findings have been brought out in a 30-page booklet, "The Timber Resources of Delaware." Announcement of publication is made by Ralph W. Marquis, director of the Northeastern Forest Experiment Station, which carried out the study.

The report notes that lumber production in Delaware, on the rise since the thirties, was greater in 1956 than in any year since 1909. In 1956, timber cut from Delaware's forests totaled 13.6 million cu. ft. of wood for sawlogs, pulpwood, piling, veneer bolts, fuelwood, excelsior, fence posts, and mine props.

The inventory of timber recorded in Delaware's forests is



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divided into three classes: sawtimber trees, 52%; poletimber trees, 35%; and cull trees, including hardwood limbs.

Total volume of Delaware's growing stock (sawtimber trees plus poletimber trees) is 483 million cu. ft. Much of this is in trees that are still too small to be very valuable.

That part of the total which could be converted into lumber amounts to 1135 million board-feet. Almost half of this timber volume is pine—mostly loblolly, but also shortleaf and Virginia pine. Hardwoods most commonly harvested are the oaks, yellow-poplar, and sweetgum.

This survey, the first really comprehensive study of Delaware's woodlands, is part of the nationwide evaluation of America's forests being made by the Forest Serivce.

Copies of the report are available upon request from the Northeastern Forest Experiment Station, 102 Motors Ave., Upper Darby, Pa.

Tree Planting

Forest industries of the United States this season are setting an all-time record for tree planting, according to American Forest Products Industries.

J. C. McClellan, chief forester for AFPI, said lumber, pulp-paper, plywood and other companies are expected to plant approximately 362,325,000 trees on their own lands during the planting season ending this month. On the basis of 1000 trees an acre, this means 362,325 acres of new forests.

The unprecedented planting program, he said, represents an increase of 8% over plantings on forest industry lands a year ago.

"While nature is still the great reforestation agent, it is clear that tree planting is becoming increasingly important, especially on lands which do not readily reseed themselves," said McClellan. "Millions of acres of forest plantations are now embraced in the Tree Farm program."

This season's industry planting forecast was based on trends established during the past five years. Numerous forest industries now operate their own tree nurseries, although state-owned nurseries are still the greatest single source of planting stock.

While industry planting will be heavy in all parts of the country, most of it will be done in the South, according to a nationwide sampling of forest industries.

Map Paper

Synthetic fibers added to the paper stock considerably enhance the strength characteristics of map paper, according to a National Bureau of Standards evaluation for the Army Engineer Research and Development Laboratories. Of the different fibers investigated, polyesters give the best dimensional stability—a prime requisite in military map paper. Paper containing polyamide fibers has excellent folding, tearing, and bursting strengths, but low dimensional stability. The evaluation was made by comparing test results with results from similar tests on conventional paper stocks.

Sulphite Waste Liquor

Less sulphite liquor has gone into Wisconsin streams each year for the past eight years. Almost two thirds of all sulphite solids from the pulp mills now are utilized or processed before disposal to abate pollution, Stanton W. Mead points out in his annual report as president of the Sulphite Pulp Manufacturers' Research League released recently. Mr. Mead also is president of Consolidated Water Power & Paper Co.

In 1951 the 13 Wisconsin mills in the league utilized or processed 15.6% of their sulphite solids. In 1958 this figure climbed to 63.5%, up about 5% from 1957.

"It is particularly encouraging that utilization increases far faster than disposal," Mead comments in his annual letter to the League membership. "These materials of forest origin no longer go to waste but are now being turned into

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useful products. This fuller utilization of natural resources is true conservation in the finest meaning of that greatly overworked word."

In 1958 these 13 mills utilized 205,000 tons of sulphite solids, almost $2^1/_2$ times as much as went to treatment for disposal. Biggest use, 35%, was evaporation for fuel. Other uses in order of importance were torula yeast 25%, roadbinder 13%, 10% evaporated products for sale, 17% other uses.

Of 84,000 tons that went to disposal processes designed to reduce the oxygen demand upon streams, 74% went to various types of soil filtration, and 26% was stored in lagoons for later release when its addition to the river would not harm aquatic life, Mead reported.

Nonskid Paper

A new economical, nonskid paper surface recently developed by Armour Research Foundation of the Illinois Institute of Technology promises to solve many problems confronting industries and businesses using or handling paper bags.

Developed for the Cromwell Paper Co., the nonskid surface is embossed on the paper. The embossing increases the coefficient of friction by several hundred per cent. This means that warehousemen and dealers can make higher stacks of bagged products such as cement and livestock feeds without the usual slippage problem encountered with smooth paper bags. The paper can also be used for wrapping with the same nonskid advantages.

For the shipper and buyer, this means bags or wrapping material made of the embossed paper will hold up better and will undergo less movement in shipment. But most of all, the new embossed paper is less expensive than other nonslip papers that are coated with either plastics or resins. This is of particular importance to those firms using bags or wrapping material in great quantities.

The Cromwell Paper Co. experimented with an embossing pattern of their own which increased the coefficient of friction by approximately 40%. It was thought, however, that surface friction could be increased even more with different embossing patterns.

Testing of papers and development of various single and double embossing patterns led ARF scientists to what is considered the optimum embossed pattern for paper giving the highest amount of surface friction without sacrificing its necessary physical properties. That pattern is the 3/32-in. double-embossed pattern with interlocking square elements. Research also showed that impact strength was increased.

Although originally developed for bags, the new paper was found to be particularly useful in wrapping steel for shipment. The paper's uniform flexibility and improved impact strength are the advantages in this application.

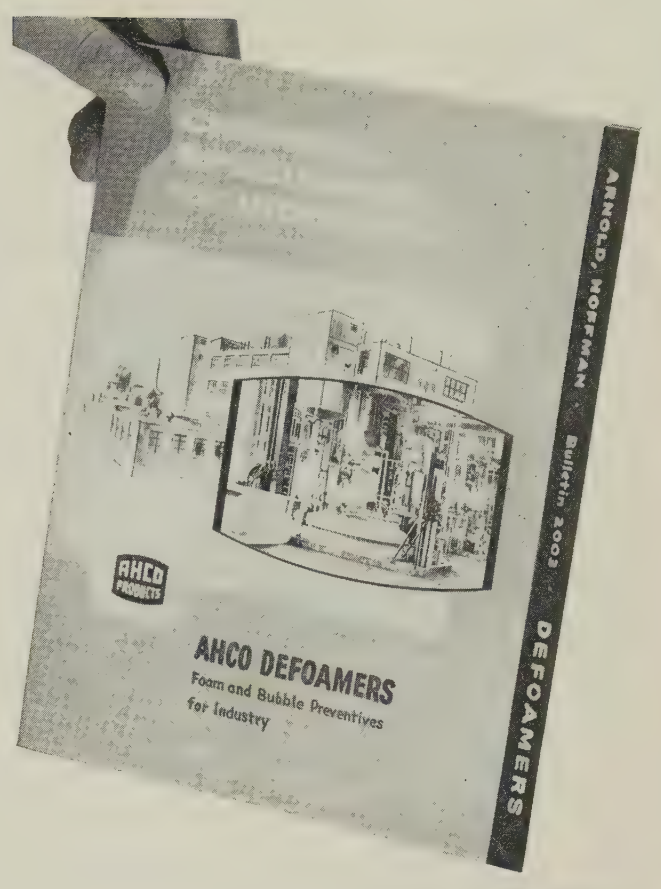
Woodpile Sampling

Color photos of stacked pulp logs are providing a scientific and money-saving answer to an age-old woodsmen's riddle—how much bark and air are in a cord of pulpwood?

The answer is important to cost-conscious newsprint producers because pulpwood is paid for by the cord, whether through direct wages or purchase. And depending on how the wood is piled, the cord of 128 cu. ft. (4 by 4 by 8 ft.) can contain anywhere from 75 to 100 cu. ft. of solid wood. The rest is air space and bark.

You can't make newsprint out of air space and bark. Yet if longer branch stumps are left on in trimming, for instance, the logs are held farther apart from each other so that the pile looks like more wood than it really is.

To confirm fair values, the newsprint companies maintain checkers to "scale" the wood as it is cut and piled in the forest. Obviously, these men are important in an operation where there is a possible variation of 33% in the quantity being paid for. Since the Canadian pulpwood harvest is



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14 million cords valued at $400 million, even a 5% variation means $20 million.

Until recently, solid-wood content of cords was checked by measurement of sample woodpiles, log by log. This was expensive. Continuing research has now led to the use of pictures which when projected on a special screen tell a hidden story as revealing as x-rays.

At least as accurate as the tape-measure crews, a photo-scaler and an assistant using photos can now do what required eight men before.

The scaler photographs the butt-ends of sample woodpiles. Color film is used because wood coloring helps identify wood type, condition, age and bark thickness. Back at base camp, the photos are projected on a 30 by 30-in. screen area containing 900 evenly distributed dots. By counting the dots that do not fall on wood in the picture, the operator can determine what percentage of the woodpile consists of bark and interstices.

One of the photo-scaling experts explains: "The law of averages permits us to assume that the proportion of wood shown in the face of the pile is the same throughout the depth of the pile. . . . Eight vertical lines have been drawn at regular intervals within the 30 by 30-in. square on the screen. Counting only one row of dots on each side of the line has proved a sound way of arriving at the proportion of solid wood in the pile. So, actually, we take samples of the samples with great saving of time and money."

—From *Newsprint Facts*, Newsprint Information Committee, New York, March, 1959.

Turbine Aeration

Free oxygen treatment administered 24 hr. a day by sulphite pulp mills whipped king-size booster shots of air into three major rivers in Wisconsin throughout 1958's months of low stream flow and low dissolved oxygen, Stanton W. Mead revealed March 9 in his annual report as president of the Sulphite Pulp Manufacturers' Research League. Mead also is president of Consolidated Water Power & Paper Co.

A huge total improvement of water conditions was accomplished by the new technique of turbine re-aeration. Four sulphite mills thus put back into solution about 2,400,000 lb. (1200 tons) of life-giving oxygen for aquatic animals to breathe. This is more oxygen than is contained in a cube of air as high as a 52-story building. At one mill where the incoming water already had lost most of its oxygen to upstream pollution, the waterpower turbines daily restored to the Wisconsin River 27% as much oxygen as the stream picks up by natural regeneration in the next seven miles of flow, Mead pointed out to the league membership.

"Turbine aeration is the one workable method thus far available for doing something to improve the water in a stream after the oxygen has fallen below a desirable level," he explained. "Its action is remedial, as compared with the preventive action of abatement by keeping undesirable effluents out of the stream. Prevention will always be preferable to cure, but turbine aeration now affords a valuable supplementary stream improvement tool where geography and turbine design permit applying it."

Turpentine

Predicting that the pulp industry "will be the principal source of turpentine long before 1957," a speaker at a meeting in Ponte Vedra Beach, Fla., of the Pulp Chemicals Association said that technology is opening new directions to a product so famed even in Elizabethan times that it gained notice in Dr. Johnson's Lexicon.

Ernest E. Holdman, former vice-president and general manager of the International Division of Heyden Newport Chemical Corp., traced the history of naval stores in the United States for members of the Association's Sulphate Turpentine Division, and told them that today's terpene specialist can develop the expanding markets needed by the growth of sulphate wood turpentine—a paper industry by-product—as a chemical raw material.

Quoting industry figures, Mr. Holdman, well known in the naval stores industry for over 50 years, pointed out that sulphate wood turpentine accounts for more than 50% of the crude turpentine produced in the United States yearly. He said that the "great bulk of it goes into the manufacture of terpene-based chemicals and there is room for more." Continued terpene research has led to the development of perfumery components, for example, and flavoring materials such as menthol, thymol, and neomenthol, with newer products for insecticides, rubber chemicals, and plastics forecast.

In reviewing the history of naval stores, Mr. Holdman identified the term as "one of the oldest industries in America, if not the oldest." Supplying shipbuilders of the day, "it began in Nova Scotia, and by the middle of the 17th century was prospering along the Connecticut river and in Massachusetts. Later the colonists soon evolved a method of recovering the volatile part and, as exporters of turpentine, did a land office business."

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"As long as industry keeps recovery in high gear and its idea of values within reach of the processor," Mr. Holdman stated, "sulphate wood turpentine can be consumed right here at home in the forseeable future and need not compete in the world markets with Russian, Chinese, or any other origin turpentine."

Inland Waterways

Use of inland waterways for the movement of chemicals has increased by 260% in the last 10 years according to Frank G. Moore, general traffic manager for the Columbia-Southern Chemical Corp.

In an address in Cleveland April 30 before the Manufacturing Chemists Association, Mr. Moore said that approximately 10,170,000 tons of chemical products were shipped on United States inland waterways system in 1957 as compared with 2,800,000 moved by water only 10 years earlier.

Mr. Moore predicted that "over the next 10 years, it will be reasonable to anticipate an annual growth in inland waterways traffic in excess of 4%."

Water transportation is the oldest form of transportation and was used by the Phoenicians as far back as 1200 B.C. The Phoenicians traded in chemicals, referred to as incense and spices and also precious metals. Today, everything from common sand and chemicals to precious metals is shipped by water.

History is repeating itself, Mr. Moore stated. With the advent of the railroads and their rapid expansion throughout the country, water transportation almost disappeared. In the last decade or two this situation is being reversed and water transportation, not only of chemicals but numerous other products, is growing rapidly.

Exclusive of the Great Lakes, the United States has a total of some 29,000 miles of navigable streams—a water highway greater than the circumference of the earth. In addition, the distance from Duluth on Lake Superior to Oswego on Lake Ontario adds another 1140 miles. These waterways are free of any tolls or duties under a policy originally established by the Northwest Ordinance in 1787.

Among numerous other commodities, chemicals are taking increasing advantage of the waterways system of this country. As the volume and variety of chemicals increase, so does the specialization in barges and vessels to handle it.

Mr. Moore pointed out that chemicals are moved in open hopper barges, covered barges, tank barges, and even in what are sometimes referred to as thermostype barges such as those now in service for molten sulphur.

Due to the nature of the products shipped such as compressed gases and chlorine, pressure vessels are required, with particular emphasis on safety devices. He stated that Columbia-Southern pioneered in the design and use of pressure vessels for water shipment of chlorine as early as 1942.

Among the materials moving in liquid form and which must be kept warm in transit to facilitate unloading are caustic soda and asphalt, also molten sulphur moving at 350°F. In contrast, liquid methane is moved at −250°F. Both the shippers and the barge operators have learned how to provide this transportation so that it can be done with safety to the public and protection of the product, according to Mr. Moore.

An ever-increasing number of industries, chemical and otherwise, are finding water transportation attractive for raw materials and finished products and are constructing plants adjacent to navigable streams. Last year over 400 industries decided upon waterside locations. In less than seven years over 2800 waterside industrial projects have been started. Just how many of these were chemical plants is not known.

Mr. Moore warned that it should not be assumed from the great growth and variety of movement of products by water

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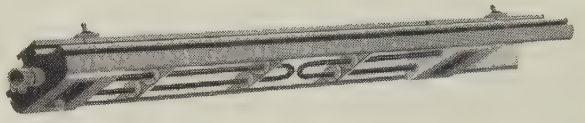

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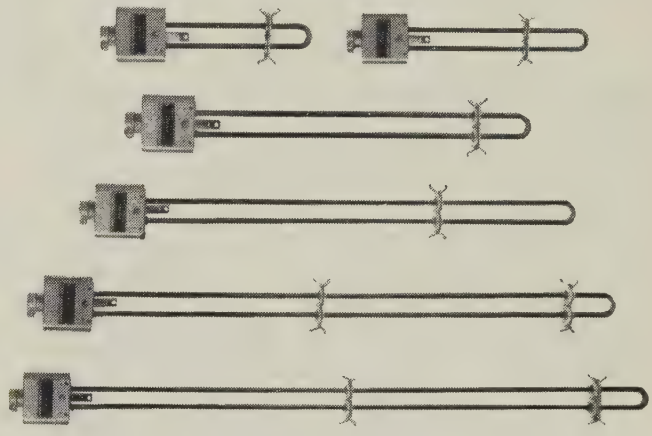

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that that method of transportation is always cheapest. While it is an economical method, each movement requires individual study and a number of factors must be considered. Some of the more important items are: size of barge, marine insurance, cost of placing the material alongside barge as well as removing it from the barge to the point of use, shrinkage, additional storage facilities required, capital tied up in inventory, all of which add up to capital investment.

Industrial Wastes Committee

The Special Research Meeting of the National Technical Task Committee on Industrial Wastes, held at the United States Public Health Service's Robert A. Taft Sanitary Engineering Center in Cincinnati, April 27–28, closed on a note of optimism concerning progress in water pollution. The members of the committee, however, restated their awareness of the need for close cooperation between government and industry in meeting the problems in water supply and water pollution now facing the nation.

The 60 scientists and business executives in attendance met to review current industrial waste treatment research and to be briefed on the aim, scope, and direction of water research at the Sanitary Engineering Center. Ray S. Glynn of the Association of American Railroads and NTTCIW chairman stated the special research meeting was called "in recognition of the vital importance of keeping industrial waste treatment research current with the expanding population and increasingly complex technology of modern industry." The group functions as a central clearing house on industrial waste and water pollution information and to maintain priorities for research in this field.

Based on the reports received by the NTTCIW during the special meeting, the committee concluded that improved communication on water pollution between government and industry was an important requirement for future progress, a point made during the opening session by both Harry G. Hanson, director of the center, and Bernard B. Berger, chief, water supply and water pollution research.

Harry A. Faber, research grants coordinator for the PHS engineering resources program, told the group that research grants in the water field awarded during the present fiscal year now total approximately $1,350,000 and support 117 projects. He presented the specific information on work underway, and related it to the comittee's recommendations.

The sanitary engineering center reports on research dealt with activities in waste characterization, industrial waste treatment, stream studies, sewage treatment, and water treatment.

The specific projects reported on were as follows:

Waste characterization: studies on the treatability and persistence of specific organic compounds, fish bioassay studies, and characterization of wastes from catalytic cracking of petroleum.

Industrial wastes treatment: sanitary engineering center consultation with industry, studies on the effect of toxic heavy metals on biological treatment processes, studies on the conversion of sugars in spent sulphite liquor to fumaric acid, studies on the selection and adaptation of microorganisms to degrade specific wastes, and development of an industrial waste guide for uranium ore refineries.

Stream studies: studies on organic contaminants, microbial contaminants, dissolved oxygen requirement of fish, and other cooperative studies at the Corvallis field station, and effect of impoundment on dissolved oxygen.

Sewage treatment: waste stabilization ponds, studies on biooxidation surfaces, treatment of sewage by anaerobic contact, and studies on soil absorption of liquid effluents.

Water treatment: municipal water treatment studies, and studies on nuisance organisms.

Spent Sulphite Liquor

The following is an abstract of Biochemist A. H. Romane's report.

Spent sulphite liquor has long been recognized as a serious water pollutant. The pollutional effects of this waste are due principally to the presence of large quantities of fermentable sugars. It has been estimated that for each ton of sulphite pulp produced, 400 lb. of sugar appear in the spent liquor. Therefore, a small mill manufacturing 100 tons of pulp per day may discharge as much as 20 tons of sugar per day in its waste. Thus, this waste, as well as being a serious pollutant, may also be considered as a raw material.

Fermentation processes have generally been shown to be of great value in the utilization of dilute, impure sugar solutions. The application of these methods has resulted in the production of ethyl alcohol and feed yeast from spent sulphite liquor. The process under study in this laboratory utilizes a fungus to convert sugars in spent sulphite liquor to fumaric acid, a valuable intermediate in the production of plastics and resins.

The high ratio of fermentable sugar to available nitrogen and phosphorus makes spent sulphite liquor a suitable substrate for fumaric acid fermentation, since good yields of this acid are obtained only when nitrogen and phosphorus concentrations are limiting with respect to growth. The optimum amounts of these nutrients to be added to the liquor were determined by experiment and found to be critical.

Successful fermentations have been carried out with calcium base liquors, obtained from the pulping of sprucewoods. In experiments to date, 87% of the total sugar has been removed with a weight/weight conversion to fumaric acid of 41%, giving a total yield of 36%. Experiments are in progress to determine optimum fermentation conditions for the purpose of increasing yields and shortening fermentation time. Experimental answers to the following questions must be gained in order to assess the ultimate applicability of this process: (1) How rapidly can this fermentation be carried out? (2) Can fermentations with concentrated liquors be carried out efficiently? (3) Is a continuous process feasible? (4) How economically can the fumaric acid formed be recovered?

Management Awards

The names of companies which it has certified to be "Excellently Managed" in their industry for the year 1958, have

been announced by the American Institute of Management, a not-for-profit research and educational foundation devoted to the advancement of management.

The citations, based on the institute's continuing analysis of corporations in the United States, Canada, and Europe, are designed to "bring deserved recognition to those companies whose managements are doing most to increase productivity, with accompanying benefits to employees, shareholders, their plant communities and to the economy as a whole."

Audited according to the institute's point system of appraisal in 10 key management functions, the following companies studied by A.I.M. in the pulp and paper industry achieved more than the minimum 7500 points for excellence out of a possible 10,000.

Brown Co.
The Champion Paper and Fibre Co.
Crown Zellerbach Corp.
Fibreboard Paper Products Corp.
Great Northern Paper Co.
Hammermill Paper Co.
Hinde and Dauch Co. of Canada Ltd.
International Paper Co.
Kimberly-Clark Corp.
The Mead Corp.
Olin Mathieson Chemical Corp.
Powell River Co. Ltd.
St. Regis Paper Co.
Scott Paper Co.
Sutherland Paper Co.
Union Bag-Camp Paper Corp.
West Virginia Pulp and Paper Co.
Weyerhaeuser Timber Co.

Finland

A general tightening characterized the export market of Finnish forest industry products. This was reflected above all in the pulp and paper industry in which it was necessary to cut down production quite considerably. The declining development in exports which had already started in the previous year was caused principally by the rapid expansion of production capacity in major pulp and paper producing countries. Weakening economic activity in the most important markets was an additional factor. As a result, exports of forest industry products fetched very unsatisfactory prices. The export price of sawn goods, pulp, and paper was considerably lower in 1958 than in the previous year, proving that the devaluation of the Finnmark in September, 1957, was more than necessary to counteract the continued weakening of ability to compete in the international market. The value of forest industry exports last year was c. 173,000 m.mks (146,000 m.mks in 1957), a rise of 18.5%. Exports of round wood rose from 17.1 to 19.3 m.mks. The value of exports originating from wood was 18% higher (192,000 m.mks) than in 1957. Round wood and the forest industry together accounted for 77.6% of the total value of exports last year.

The volume of exports dropped from the index figure of 117 in 1957 (1954 = 100) to 114 points in 1958.

The marketing of mechanical pulp (groundwood) proved even more difficult last year than in 1957. The total exported was 143,165 tons, c. 21,500 tons less than in the preceding year. Mechanical wood pulp exports last year earned 2,922 million marks, which is slightly less than in 1957. The total production of mechanical pulp and defibrator pulp was almost exactly the same, 982,523 tons, as in 1957. This figure includes 145,888 tons for the fiber building board (wallboard) industry, c. 10,000 tons more than in the previous year. 836,635 tons was produced for the paper and paperboard industry, and the paper industry's own consumption was 595,784 tons. The paperboard industry's consumption was 83,679 tons.

The biggest buyer of mechanical wood pulp was Great Britain (74,550 tons), followed by: France (28,663 tons),

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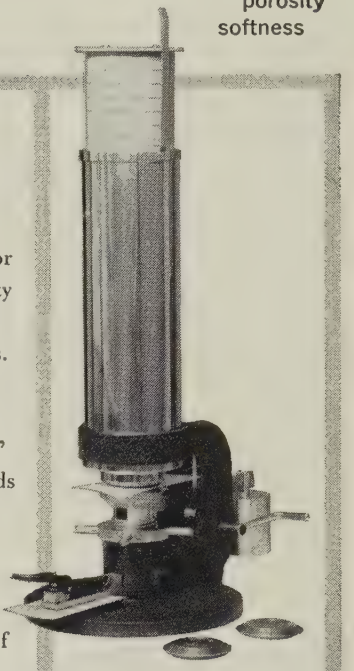

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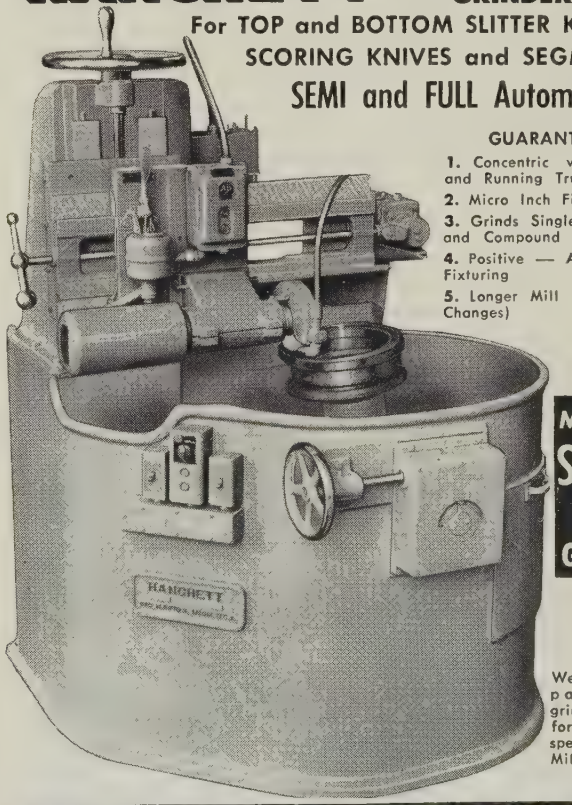

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the Soviet Union (10,043 tons), the U.S.A. (7700 tons), Italy (4297 tons), and Argentina (2696 tons).

Chemical Wood Pulp

Exports of chemical wood pulp totaled c. 1,201,000 tons, c. 30,000 tons more than in 1957. The rise was caused mainly by the increased export of sulphite pulp, excluding dissolving pulp. Exports of sulphite pulp amounted to 724,978 tons (697,473 tons in 1957) and of sulphate pulp to 476,166 (474,192 tons in 1957). Chemical pulp exports earned 46,192 million marks, c. 6800 million more than in the preceding year.

The total production of chemical wood pulp was 2,080,000 tons, which is nearly the same as in 1957.

The biggest buyers of chemical pulp were Great Britain (360,682 tons), France (166,514 tons), Western Germany (96,866 tons), the U.S.A. (68,350 tons), Poland (68,255 tons), The Netherlands (67,153 tons), Brazil (60,160 tons), and the Soviet Union (56,994 tons).

The total amount of paper exported last year was 972,350 tons (949,424 tons in 1957), of which newsprint accounted for 584,514 tons (550,591), kraft paper for 162,438 tons (170,141) and other paper qualities for 225,398 tons (228,692). The increase in the total exported, c. 23,000, consisted thus of newsprint. The value of 1958 paper exports amounted to 49,106 m.mks, about 7700 m. more than in 1957.

Great Britain was the biggest customer for all paper qualities, buying 172,956 tons altogether, and she was first also among the newsprint buyers, 122,126 tons. Next in order were the U.S.A. 100,923 tons, and West Germany 63,793 tons.

The total production was almost exactly the same as in 1957, 1,165,635 tons. Of this, c. 612,000 tons was newsprint, about 218,000 tons kraft paper and the rest other qualities.

After a very big increase in paperboard exports (including kraft liner) in 1957 there was a certain slackening in trade last year. Total exports were 315,679 tons, c. 25,000 tons bigger than in 1957. The total value of paperboard exports rose to 14,250 m.mks, an increase of about 3260 million over 1957. The 1957 production record (442,255 tons) was passed by c. 35,000 tons.

Wallboard exports grew considerably last year, reaching 83,401 tons. The export value rose from 1445 m.mks to 2327 m. The increase in exports was mainly hardboard, from 40,351 tons in 1957 to 58,182 tons last year.

Total wallboard production last year was 139,000 tons, of which porous wallboard accounted for 53,000 tons and hardboard 86,000 tons. The biggest buyers were: Western Germany (10,336 tons) The Netherlands (9331 tons), and Great Britain (9018 tons).

The considerable decrease in exports to the Soviet Union caused a setback for these products last year. Total exports reached 42,844 tons last year compared with 55,300 tons in the previous year. In value, the decrease was about 600 million marks.

—From *Finnish Paper and Timber*, No. 2, 1959.

Consolidated Water Power

The pulp and paper industry's first commercial scale installation of a new soda ash recovery process is now in operation at the Wisconsin Rapids Division of Consolidated Water Power & Paper Co.

Western Precipitation Corporation's process developed by Robert Q. Boyer and the late Linn Bradley is based on a sulphide recycle technique. It covers pulping chemicals and heat from spent sulphite liquor for reuse in pulp manufacturing and is a major stream improvement measure on the Wisconsin River. This chemical recovery prevents discharge of collectible liquor into the river.

The new process opens new horizons in sulphite and semichemical pulping. Soda-base pulping compared with the conventional calcium-base pulping yields an improved pulp from a wide range of woods; however, the high costs of chemicals have restricted its use. Recovery of chemicals through use of the new process makes possible the economic application of soda base pulping. A substantial increase in the company's use of northern mixed hardwoods which are in abundant supply close to the mills is expected to result.

One digester in Consolidated's 100-ton-per-day pulp mill has been modified to employ soda-base sulphite pulping. If the new plant performs as hoped for, the company expects to expand the recovery plant's capacity to process all recoverable spent sulphite and semichemical liquor from the entire mill.

Stanton W. Mead, company president, stated that Consolidated considers the new plant as experimental and is confident but not yet certain of its performance.

"We are, of course, sure the new plant will produce heat, soda, and sulphur for reuse in our pulping operations," declared Mr. Mead. "We cannot be certain of operating efficiency and actual cost until the plant has operated quite a while. Sustained operations will provide our company with the information we need for deciding wisely about its expansion. If it turns out as we expect it would undoubtedly provide the answer to pollution abatement at this mill. It is of equally great importance in the interests of conservation that the processes which are adopted by the industry to improve Wisconsin's streams shall prove not only effective but also economically supportable."

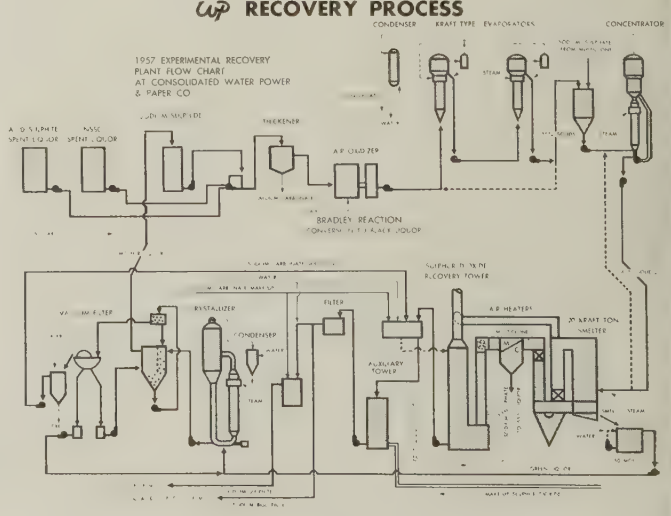
More than three-quarter million dollars have been invested in this recovery plant.

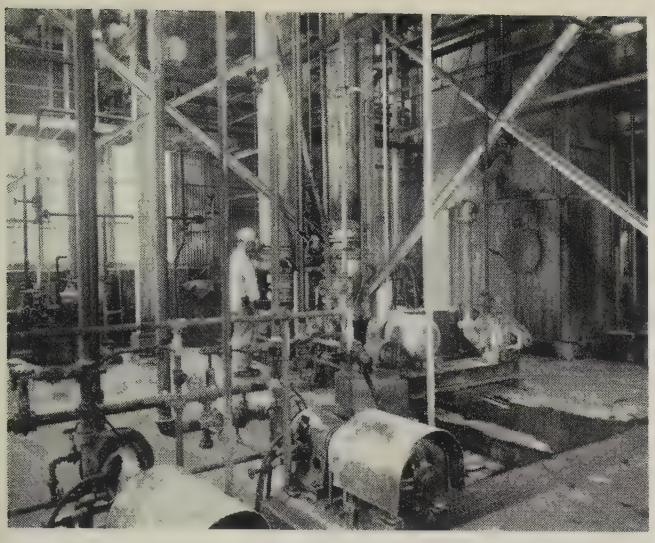
Basic principle of the process is the conversion of spent sulphite liquor into a noncorrosive solution that resembles the air-oxidized black liquor in kraft recovery. It is this similarity which allows standard kraft recovery equipment to be used. Earlier attempts at sulphite recovery required specially designed equipment to withstand the highly corrosive action of untreated spent sulphite liquor.

One of the major features of the new process is its ability to treat spent liquor from neutral sulphite semichemical, sodium acid sulphite, or even kraft pulp, and allows intermixing of liquors if desired. This development makes it possible for a manufacturer with two or more different processes operating in one mill to set up a single recovery system.

The spent liquor from the pulping process is treated with sodium sulphide and sodium carbonate (which have been recovered from a previous batch of liquor). This treatment produces a liquid which is similar in characteristics to the air-oxidized "black liquor" of the kraft recovery process.

The treated liquor is evaporated to a 65% solids concentration and burned in a recovery furnace. This furnace acts as a chemical process unit, and also as a high-pressure steam





A workman makes a final valve adjustment in the new experimental recovery plant

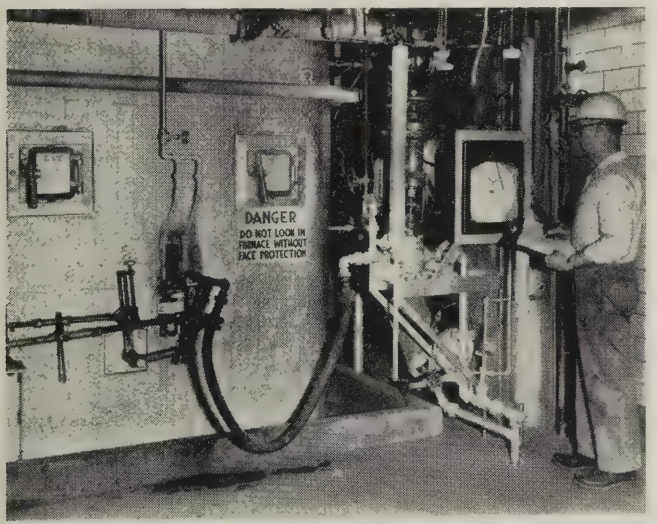
generator. Smelt formed by the combustion contains sodium sulphide and sodium carbonate in equimolar ratio even though the proportion in the incoming liquor may vary widely. This 50% sulphidity in the smelt is fixed by the release of excess sulphur into flue gases as sulphur dioxide.

The smelt is dissolved with water to create a green liquor which is evaporated to recover pure sodium carbonate crystals. Remaining mother liquor from the crystallizer is sent back to treat the spent liquor at the beginning of the cycle. The sodium carbonate crystals are filtered, washed, and dissolved.

The furnace gases with a high level of sulphur dioxide are put through a scrubbing tower where they are reacted with the purified sodium carbonate stream to create a weak sodium sulphite-bisulphite liquor. This sulphite liquor is then run through a raw acid tower where it is reacted with make-up sulphur dioxide from a standard sulphur burner. As full strength cooking liquor, it is sent to the accumulator of the chip digester.

List of Equipment Sources

The Babcock & Wilcox Co., furnace
Bailey Meter Co., instrumentation
Clarage Fan Co., induced draft fan
Crane Engineering Sales, Inc., pumps—Gould, Jabsco, Labour, Milton, Roy, and Viking
Dorr-Oliver, Inc., Dorrclone
Felker Brothers Manufacturing Co., stacks and tanks
General Electric Co., motors, starters, electrical equipment
General Blower Co., gas booster fan
Ingersoll-Rand Co., air compressor
Infilco, Inc., clarifier and sand filter
Mixing Equipment Co., mixers
Roots-Connersville Blower Division of Dresser Industries, Inc., blower
Swenson Evaporator Co., evaporators, crystallizer, condenser
Wallace & Tiernan, Inc., feeder
Western Precipitation Corp., air oxidizer, scrubbing tower, and multiclone
Wisconsin Bridge & Iron Co., steel framework and aluminum siding
Worthington Corp., pumps
L. J. Wing Manufacturing Co., Division of Aero Supply Mfg. Co., Inc., waste heat air fan



Stream improvement plant in operation at the Wisconsin Rapids Div. of Consolidated Water Power & Paper Co. processes spent sulphite liquor which was formerly discharged into the Wisconsin River. The plant, now in full-scale operation, is the first commercial scale installation of a new soda ash recovery. Pictured above is the furnace where spent liquor is burned to regenerate pulping chemicals and produce steam

Rayonier

George E. Scofield has been named general manager of Rayonier cellulose operations, it was announced April 24 by Russell F. Erickson, president. This is a newly created executive post at Rayonier and will be headquartered at executive offices in New York. Mr. Scofield is currently resident manager of the company's Jesup, Ga., division, largest in the Rayonier group in the United States and Canada.

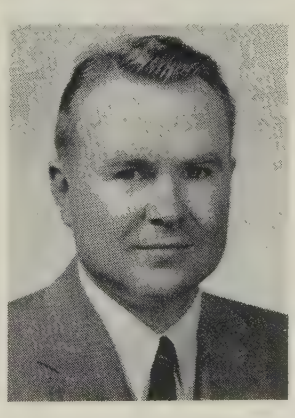
The company also announced the appointment of Blanton W. Haskell as resident manager of the Jesup division and of Bryan L. Rauschert as resident manager of the company's Fernandina (Florida) division, succeeding Mr. Haskell. Mr. Haskell replaces Mr. Scofield at Jesup.

At the same time two other executive changes in the Rayonier manufacturing department were also announced. Lowell M. McGinnis, now assistant resident manager at Jesup for manufacturing, becomes assistant resident manager at the Grays Harbor, Wash, division to replace Mr. Rauschert. John F. Hooper, currently pulp mill superintendent at Jesup, has been promoted to the position of assistant resident manager at the Port Angeles, Wash., division. He replaces R. H. Richmond who is returning to Rayonier's Canadian subsidiary, Alaska Pine & Cellulose Ltd. of Vancouver, B. C.

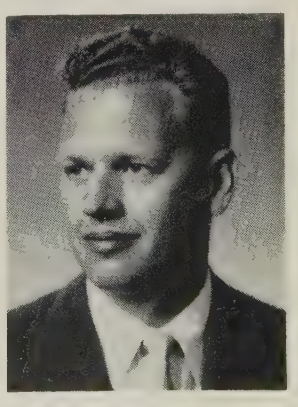
All appointments were effective May 1.

D. K. Smith has been appointed to the post of assistant manager of Rayonier's Eastern Research Division, it has been announced by R. L. Mitchell, the division's manager.

Mr. Smith, among the youngest cellulose chemists (he is 31), holds his B.S. from Utah State University and Ph.D. from Purdue University. He joined the chemical cellulose division as silvichemical producer in 1954 upon completing his doctorate. In his new capacity his duties will in clude research coordination and customer contact at this third and newest of the company's research centers. Its two others are at Shelton, Wash., and Vancouver, B. C.



G. E. Scofield, Rayonier, Inc.



B. W. Haskell, Rayonier, Inc.

The New Jersey research station concentrates its studies primarily upon the basic technology of chemical cellulose produced from wood and its conversion to such end products as tire cord, cellophane, and new types of cellulose-base fibers.

Scott

Keeping pace with the dynamic industrial and economic growth of the South, Scott Paper Co. April 24 shipped from its Mobile mill a freight car containing the first of its nationally-known household paper products ever produced in this area.

Paul C. Baldwin, vice-president in charge of Scott's manufacturing, engineering, and research operations, sent the initial carload on its way after sealing the box car door in significant ceremonies staged at the firm's Southern Division plant at Mobile, Ala.

"To meet the tremendous growth in demand for Scott's household and industrial paper products in the South," Baldwin said, "Scott Paper Co. has now built its first tissue mill in this section of the country. We are proud of our new modern mill. We are proud of our Scott employees. And we are proud to be able to say Scott products are now being made here along with the fine Hollingsworth & Whitney specialty papers."

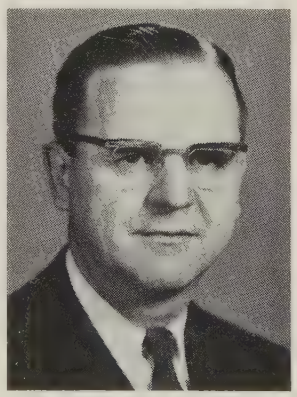
These ceremonies also represented an important step in Scott's expansion program designed to equip the Mobile mill with sufficient facilities to become the South's principal producer of Scott products for distribution to rapidly growing Southern markets. Completion of the 20 million dollar program is expected early next year.

The mill is currently producing the company's three bathroom tissues—Soft-Weve, ScotTissue, and Waldorf—and ScotTowels, the largest selling household paper towel in America. A number of the company's well-known industrial brands also are being produced here. These include Scott UHA, singlefold and multifold paper towels; ScotTissue and Waldorf bathroom tissues, and Scott Wipers for the industrial and automotive fields.

Oxford

Oxford Paper Co. has announced the appointment of Delbert J. Morrison to the position of director of planning.

This is a new position at Oxford which emphasizes the importance being given to forward planning by this company. Mr. Morrison has been executive secretary of Oxford's Long Range Planning Committee since 1955 and will continue to function in that capacity. As director of planning Mr. Morrison will report to the vice-president, research and development, and will be concerned with the formulation and integration of all Oxford planning activities, both short and long range.



D. J. Morrison, Oxford Paper Co.

Mr. Morrison will continue to be located in Rumford, Me.

KVP

Morris Kane, technical director for The KVP Co. will be in charge of a new fundamental research group recently formed at the company's Kalamazoo plant, it was announced by Robert D. Caine, vice-president of manufacturing.

Designed to broaden the scope of KVP's product development program, the purpose of this new research group will be to provide solutions to fundamental product development problems and also find practical applications of these solutions through cooperation with pilot laboratory, engineering, and production personnel.

In order to assume certain responsibilities previously held by Mr. Kane, appointment was made of Robert Paris to laboratory administrator from supervisor of the plant's quality control section.

Laboratory member Gerald Ritzema has been appointed acting supervisor of the quality control section.

Other department heads in KVP's main laboratory will remain the same: Leo Lake, supervisor of the research group; R. C. Germanson, supervisor of mill technical service; Reginald Hurst, supervisor of customer technical service.

The KVP Co. Ltd., wholly-owned subsidiary of The KVP Co., Kalamazoo, has announced plans for the installation of a new paper machine in its mill at Espanola, Ont., Canada. This machine will have an annual capacity of 15,000 tons of bleached kraft specialty papers. The new unit will be capable of producing both machine glazed and machine finished papers.

This extra capacity will complement existing papermaking facilities. It will ensure improved continued service, superior quality, and new grades in line with the growing needs of KVP customers.

E. Norval Hunter, president of The KVP Co. Ltd., indicated that the new unit would come into production in 1960.

Estimated cost of the additional facilities, including stock preparation equipment and auxiliaries, will be in excess of $2.5 million.

Dollar value of this equipment will be shared between United States, Canadian, and United Kingdom manufacturers. The major contract has been awarded to the Black-Clawson (Canada) Ltd.

Hammermill

Appointments of A. H. Croup as development physicist in the Research and Development Section and of Richard W. Brown as laboratory director have been announced by Technical Director Donald T. Jackson of the Hammermill Paper Co.

As development physicist, Mr. Croup will devote his full time to the development of electronic paper scanning devices and other equipment for the automatic inspection and counting of paper. In past years, Mr. Croup has played a leading role in the development of numerous control instruments and equipment such as the Bauer Centri-Cleaners which are now widely used in paper mills throughout the nation. He holds numerous patents in the papermaking field.

A former instructor in physics at the University of Pittsburgh, Mr. Croup came to Hammermill as a physicist in the laboratories in 1937. He was promoted to acting chief physicist in 1942, to section head of research and instrumentation in 1949, and to manager of the laboratories in 1953.

As laboratory director, Richard W. Brown will be responsible for the administration of all laboratory activities, including research in pulp and paper, applied research and development, product evaluation, and quality testing.

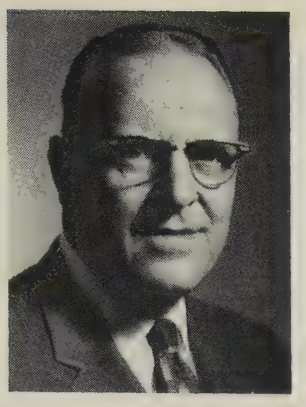
A graduate of The Institute of Paper Chemistry, Mr. Brown joined the Hammermill organization in 1950 as a research chemist in the laboratories. In 1953 he was promoted to head of the technical control section, and in 1956 was appointed assistant manager of the laboratories.

Brown

Appointment of Conrad T. Waldie to the position of technical assistant to the president has been announced by A. E. H. Fair, president of Brown Co., northern New England manufacturer of pulp, paper, and related forest products.

Mr. Waldie's duties will include, according to the an-

C. T. Waldie, Brown Co.



F. S. Leinbach, Riegel Paper Corp.

nouncement, appraisal and evaluation of reports relative to operations, research, and development projects. His duties will also include day-to-day liaison between production and sales.

Mr. Waldie, who holds a B.S. degree in Chemical Engineering from the University of Pennsylvania and a Master's degree in Business Administration from Harvard University, has been associated with Brown Co. since 1952, and has served in various capacities including supervision of Nibroc Towel production and more recently as assistant to the technical director, George A. Day.

Construction of Brown Co.'s new Bermico plant on the outskirts of Birmingham, Ala., started in May, according to a statement issued by A. E. H. Fair, president of the northern New England pulp, paper, and forest products firm which is also one of the nation's leading producers of fiber sewer pipe and conduit.

The new plant, Fair said, will be about the same size as Brown Co.'s Corvallis, Ore., Bermico plant and is expected to be completed late this year. R. W. Andrews, a vice-president of Brown Co., will supervise construction, and equipment design will be handled by Bernard Guthrie, plant manager at Corvallis. Negotiations for the plant location were handled by Arthur Taylor, general manager of Brown Co.'s Bermico Division.

Riegel

Riegel Paper Corp. has announced the election of Frederick S. Leinbach as president. John L. Riegel, who has been chairman of the board and president, will continue as chairman of the company.

Mr. Leinbach has been executive vice-president of the corporation since 1957. He joined the Riegel organization in 1934, starting as a chemical engineer for product development in the company's mill at Milford, N. J. He is a member of the board of governors of the American Paper & Pulp Association, currently serving as chairman of the Chemical Additives Committee, and as chairman of the Glassine & Greaseproof Association. He has served as president of the Packaging Institute and, during World War II, was assistant director of the War Production Board's Container Division.

Mead

Since the first of the year, work crews have been clearing the area adjacent to The Mead Corp.'s Sylva (N. C.) Division in preparation for the erection of a new steam plant for the paperboard mill.

Construction will get underway immediately and the new installation which will cost more than $\$1^1/_4$ million is expected to be completed about Jan. 1, 1960. General contractor for the project is the Jamison Co. of Atlanta, Ga.

The new boiler, when completed, will tower 75 ft. in the air. Its furnace, bigger than most two-car garages, will burn enough powdered coal each hour to heat an average home for a year. The water which will be evaporated into steam in the boiler each day will be sufficient to supply the needs of a city of 3000 persons.

Babcock & Wilcox has fabricated and will install the new boiler designed to replace six older boilers which now supply the mill's steam requirements. However, one of the present boilers will be converted to burn bark from the wood used at Sylva.

The installation will be along the lines now quite popular, particularly in Southern utility plants, with the boiler proper installed outdoors. The firing aisle and machinery areas will be housed in a steel framed building with protected metal siding.

The new boiler is expected to provide more adequate and reliable supply of steam than the present equipment. The higher efficiency will permit the Sylva Division to increase production and reduce the cost of steam generation.

The new boiler will generate 200,000 lb. per hr. of steam of 600 p.s.i. and 740°F. Provisions have been made so that the boiler can also be operated at 850 p.s.i. should it ever become desirable to generate electric power.

Being of the latest design, the boiler will be equipped with mechanical separators to control fly ash and a complete automatic combustion control system. Existing coal and ash handling facilities will be extended with Link-Belt coal conveyor, Stock coal scales, and United pneumatic ash handling.

Allied

Gunther Baldauf has been appointed research manager of the Allied Paper Corp.

A graduate of the Massachusetts Institute of Technology, Mr. Baldauf has been the research chemical engineer for the last 10 years with the Ecusta Paper Division of the Olin Mathieson Chemical Corp.

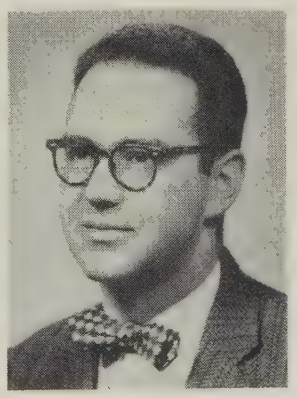
O-I

A new Research, Product Development, and Standards Laboratory to combine and correlate all facets of the design, engineering, and testing of corrugated and solid fiber boxes, has been established by the Paper Products Division of Owens-Illinois Glass Co.

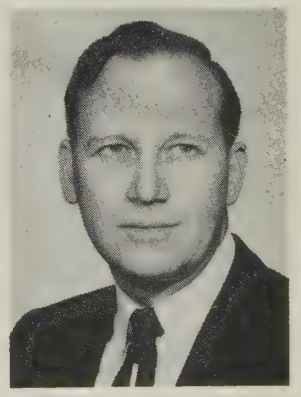
Technical director of the new facility will be John G. Turk, for the past 10 years director of the Packaging Research Laboratory of the Glass Container Manufacturers Institute.

Edwin D. Dodd, vice-president and assistant general manager of the Paper Products Division, said the laboratory will combine "all of the factors that must be included in any approach to packaging—including field experience, packaging development work, and mill research."

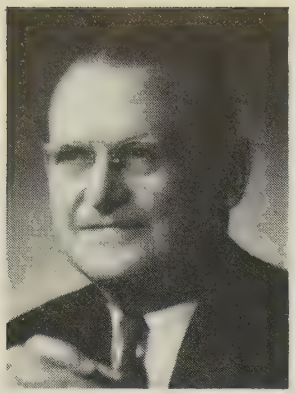
The new laboratory, Mr. Dodd said, "will parallel in packaging the extensive research being done in raw materials by the company's Mill Division Laboratory."



Gunther Baldauf, Allied Paper Corp.



J. G. Turk, Owens-Illinois Glass Co.



S. W. Yates, Robertson Paper Box Co., Inc.

C. S. Huestis, Continental Can Co., Inc.,

ROBERTSON PAPER BOX

The appointment of Sampson W. Yates as vice-president in charge of production of Robertson Paper Box Co., Inc., Montville, Conn., was announced at the annual stockholders meeting on Feb. 24, 1959, by Ralph A. Powers, president.

Mr. Yates graduated from the University of Toronto with a degree in Mechanical Engineering and he was one of the first technical men to enter actual manufacturing operations in the paperboard and paper box industry.

Mr. Yates has been with Robertson Paper Box Co., Inc. for the past nine years as production manager. He was formerly associated with The Gardner Richardson Co. and the Spanish River Pulp and Paper Mills.

CONTINENTAL CAN

In a joint statement by General Lucius D. Clay, chairman of the board of directors of Continental Can Co., Inc., and Harold M. Treen, president of Fort Wayne Corrugated Paper Co., it was announced that Continental Can has entered into an agreement to acquire all the assets and business of Fort Wayne Corrugated in exchange for 496,000 shares of Continental Can common stock and the assumption by Continental Can of the liabilities of Fort Wayne Corrugated.

Upon completion of the transaction, the liquidation of Fort Wayne Corrugated will take place and the common stock of Continental Can will be distributed on the basis of 0.765654 share of Continental Can for each share of Fort Wayne Corrugated.

The transaction is subject to the approval of the stockholders of Fort Wayne Corrugated at the company's annual meeting which was scheduled to be held on May 27, 1959.

Fort Wayne Corrugated manufactures corrugated shipping boxes and corrugated paper products in plants located in Chicago, Ill.; Hartford City, Ind.; Rochester, N. Y., and Pittsburgh, Pa. Its principal asset is 40% of the outstanding stock of Southern Paperboard Corp., the other 60% of which is owned by Continental Can. Southern Paperboard owns and operates a paper mill with an annual capacity in excess of 200,000 tons at Port Wentworth, Ga., and over 400,000 acres of woodlands in Georgia, Florida, and South Carolina. Its full production of kraft containerboard now goes to its two shareholders.

In view of the fact that the majority stock interest in Southern Paperboard is owned by Continental Can which is also responsible for management, the Department of Justice has stipulated that it will not seek to enjoin the transaction under the antitrust laws nor will the acquisition be used to prejudice the position of Continental Can under pending litigation.

According to an understanding with the Department of Justice, Continental Can has undertaken to dispose of at least two of Fort Wayne Corrugated's four box plants. In accordance with this undertaking, Continental Can is now negotiating the sale of three of the four plants—details to be announced at a later date.

C. S. Huestis has been named general manager of bleached board development for the Robert Gair Paper Products Group of Continental Can Co., it has been announced by C. B. Stauffacher, group executive vice-president.

Formerly general manager of research, engineering and development for the Paper Products Group, Mr. Huestis will now be responsible for the planning and construction of a new bleach board and paper mill in Augusta, Ga. Upon completion, operation of the mill will be assigned to the group's Containerboard & Kraft Paper Division.

Keith Max, formerly manager of research and development for the Paper Products Group, has been appointed general manager of research and development, and C. A. Young, previously manager of engineering, has been named general manager of engineering. In his new position, Mr. Max will be responsible for the over-all coordination of the group's technical activities and new developments in its product lines—boxboard, folding cartons, fiber drums, corrugated boxes, containerboard, and kraft paper. Mr. Young's new job will be to coordinate the group's plans for and construction of new plants and major installations of new equipment.

W. M. U.

Competitive examinations have been administered to 36 high school seniors from Michigan, Ohio, Wisconsin, and Illinois at Western Michigan University in competition for six scholarships in paper technology.

The awards include four for $500 annually, one for $400, and one for $300. All are renewable grants throughout the college career of the holder.

Those in the top six, in order, are:

Alan Andrew Lawrence, Lodi, Ohio
Richard J. Egland, Kalamazoo, Mich.
E. Geoffrey Meyer, Marinette, Wis.
Carl Eugene Steiner, Chippewa, Ohio
Douglas Lee Bockstanz, Kalamazoo, Mich.
John Frank Kratochvi, Berwyn, Ill.

SYRACUSE

The Fourth Annual Boxboard Research and Development Association scholarship has been awarded to a Troy, N. Y., pulp and paper technology major at the State University College of Forestry at Syracuse University, Syracuse, N. Y., it was announced recently.

This year's recipient is John H. Dean of Troy (N. Y.).

The $250 scholarship was awarded by Hardy L. Shirley, dean of the College of Forestry, at a presentation ceremony held recently at the college.

The financial grant was established in 1956 by The Boxboard Research and Development Association, Kalamazoo, Mich., and is presented annually to a deserving senior majoring in pulp and paper technology. The fourth-year undergraduate who receives the scholarship must be in the upper quarter of his class, be of good moral character, and indicate a preference or interest in the paperboard field.

A Nunda, N. Y., junior specializing in pulp and paper technology at the State University College of Forestry has been awarded the Second Annual A. E. Staley Manufacturing Scholarship, it was announced recently.

Paul E. Parker, son of Mr. and Mrs. Wayne T. Parker of Cooperville Rd., Nunda, is the recipient of the scholarship.

The $500 scholarship was awarded to Parker by Dr. Hardy L. Shirley, dean of the College of Forestry, at a presentation ceremony held recently at the college.

This is the second year that the A. E. Staley Manufacturing Co. of Decatur, Ill., has given the scholarship. It is given each year to a qualified student majoring in pulp and paper

technology on the basis of satisfactory scholastic rating, good character, and financial need.

A student majoring in pulp and paper technology at the State University College of Forestry at Syracuse University has been awarded The Fourth Annual Mead Corp. Award, it was announced recently.

In a presentation ceremony held recently at the College of Forestry, the $300 award was presented to Ronald L. Benson of Syracuse, by Hardy L. Shirley, dean of the Forestry College.

Since 1956, The Mead Corp. of Dayton, Ohio, has presented this award each year to a deserving student specializing in pulp and paper technology at the College of Forestry.

In college, Benson has served as vice-president and president of the Papyrus Club, an undergraduate organization for students of pulp and paper technology; is a member of Robin Hood, junior honorary society; Alpha Xi Sigma, senior honorary society; and has participated in other extra-curricular activities.

A freshman Syracuse has been awarded the third biennial National Starch Products, Inc. Scholarship for $2000, it was announced recently.

Kenneth B. Laffend of Syracuse is the recipient.

In a presentation ceremony held recently at the College of Forestry, Hardy L. Shirley, dean of the Forestry College, presented Laffend with the four-year scholarship which provides $500 per year for four consecutive years.

In 1954, the National Starch Products, Inc., New York, N. Y., established the scholarship for freshmen who plan to major in pulp and paper technology or in plastics and cellulose technology. The requirements for the scholarship include an excellent scholastic rating in high school, good character, demonstrated qualities for potential leadership in the paper field, and financial need.

DIXON
Selector Chart for Industrial Markers

Material to be Marked	Surface Condition	NUMBERS REFER TO MARKERS ON OTHER SIDE MARKER IS DESIGNED FOR SURFACE WHERE NUMBER APPEARS	
		LIGHT DUTY MARKERS	HEAVY DUTY MARKERS
Metal			
Iron, Steel	Hot (below 1200°)	4, 11, 14, 17	4, 14, 17
Iron, Steel Welding use	Hot (above 1200°) Cutting torch lines	11, 17	17
Iron, Steel	Normal	1, 3, 10, 11, 14, 18	1, 3, 10, 14, 18, 26
Aluminum, Brass	—40°F. to 175 F.	10, 16, 30, 14, 18, 31	10, 16, 30, 14, 18, 31
Stainless Steel, Tin	Slick — Shiny	10, 16, 30, 18, 31	10, 16, 30, 18, 31
Wood			
Lumber, boards, logs	Dry	1, 3, 10, 23, 6 25, 29, 31, 32, 33, 34, 37, 39, 40	1, 3, 10, 23, 25, 26, 31, 32, 33, 34, 37, 39, 40
Veneer, Plywood	Warm	25, 1, 3, 32, 33, 34, 39, 40	25, 1, 3, 32, 33, 34, 39, 40
Timber, logs	Wet	1, 2, 10	1, 2, 10
Timber, logs	Immersed	2, 10	2, 10
Concrete, Plaster	Dry — Damp	25, 29, 3, 10	25, 26, 3, 10
Stone, Rock, Tile	Smooth — Rough	3, 10	3, 10
Macadam, Asphalt	Cool — Cold	3, 10	3, 10
Paper, Paperboard	Dry	6, 7, 23, 8, 9, 31, 36, 37	23, 8, 31, 36, 37
Cardboard, boxes	Laminated-coated	6, 7, 23, 29, 3, 37, 10, 30, 31, 32, 33, 34, 39, 40	2, 26, 3, 10, 30, 31, 32, 33, 34, 39, 40
Glass, China	Glazed	16, 10, 30	16, 10, 30
Plastic, Film	Rigid, Flexible	16, 10, 30	16, 10, 30
Meats, hides, skins	Wet	19, 21	19, 21
Rubber, leather	Cold — warm	5, 12, 24, 28	5, 12, 27
Textiles, Cloth		13, 20, 24, 28, 8, 9, 15, 35, 36, 38	20, 27, 35, 38, 8
Canvas		13, 20, 24, 28	20, 27

This chart is for guidance purposes only. Preliminary trials should be made.

THE JOSEPH DIXON CRUCIBLE COMPANY, Dept. CSC, Jersey City, N. J.

SANDUSKY, OHIO NEW MARKET, CANADA TICONDEROGA, N.Y. MEXICO CITY, D.F.

WRITE FOR INFORMATION ON THESE OTHER DIXON PRODUCTS FOR INDUSTRY
PAINTS & ENAMELS, GRAPHITES & LUBRICANTS, CRUCIBLES & REFRACTORIES

New handy selector chart devised by the Joseph Dixon Crucible Co., which tells at a glance the proper type of industrial marker to use on almost every type of industrial material. Copies are available, free, by writing to the company's Dept. CSC, Jersey City, N. J.

Bolton-Emerson

The Emerson Manufacturing Co., Division of John W. Bolton & Sons, Inc., Lawrence, Mass., announces the Emerson Claflin 303, newly-designed continuous refiner for pulp mill defibering and paper mill refining. Superseding the No. 3 Emerson Claflin, the new unit incorporates many design innovations that permit ease of maintenance, new operating economy and efficiency.

The first conical refiner having oil mist lubrication, the Emerson Claflin 303 is equipped with two mist atmosphere lubrication devices located in the bearing pedestals. Each operates independently, supplying oil mist to each bearing. Visible oil supply and pressure gages are built into the housing. Also, a visible or audible warning system is provided for protection of the bearings.

The Claflin 303 is constructed to withstand 100 p.s.i. The discharge pipe (center or tangent, optional) is cast as an integral part of the shell to eliminate the necessity of dismantling piping when removing the large head for filling changes. Also, the redial bearing and packing box assembly can be passed through the shell filling while remaining completely intact on the shaft.

The Claflin 303 plug is designed to use segmental fillings, which provide a wide choice of materials and knife patterns as well as lighter parts to handle. Also, fillings changes are made without disturbing the bearings or packing box assemblies.

Control of the plug position is achieved through an accurate microfeed mechanism, which permits positive settings and extremely fine adjustments.

Detailed information on the Claflin 303 is available by writing The Emerson Manufacturing Co., Division of John Bolton & Sons, Inc., Lawrence, Mass.

B & W

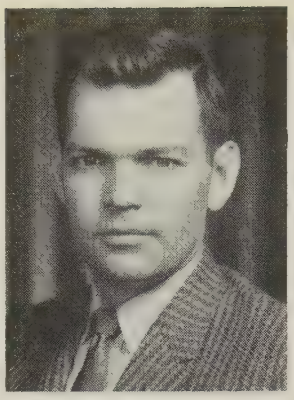
James S. Anderson, vice-president in charge of sales for The Babcock & Wilcox Co.'s Tubular Products Division, was appointed general manager of the division, it was announced April 22 by William J. Thomas, vice-president in charge of the division.

J. S. Anderson, The Babcock & Wilcox Co.

Engineers, buyers, and others involved in purchasing of pipe will be interested in a new technical data card published by the Tubular Products Division of The Babcock & Wilcox Co. This card contains the dimensions and weights per foot of pipe in sizes $^1/_8$ through 36 in. for all schedules. Copies of the data card, identified as TDC-191, are available without charge through the division's general sales offices at Beaver Falls, Pa.

Engineers, purchasing agents, and others responsible for the procurement of welding fittings and flanges will be interested in the information contained in a new booklet released by the Tubular Products Division of The Babcock & Wilcox Co. This 12-page booklet, known as FB-78, is a guide to material selection of carbon, alloy, and stainless steel welding fittings and flanges. Copies are available

without charge from the sales office of the company at Beaver Falls, Pa.



Otto Berggren, Huyck Felt Co.

Huyck Felt

Huyck Felt Co., Rensselaer, N. Y., has announced the appointment of Otto Berggren as field service engineer for Eastern New York and portions of Vermont.

Huyck Felt Co., Rensselaer, N. Y., and Aliceville, Ala., recently held the 26th in its continuing series of Felt Forums at Berkeley, Calif. Approximately 50 papermakers, representing mills in the San Francisco area, were on hand to hear several informative talks on the application of papermakers' felts.

Earl D. Rhodes, vice-president of Huyck, discussed the design and manufacture of felts, emphasizing the construction engineering required to provide a felt for a particular job.

Otto Berggren, field service engineer, discussed two Huyck services: the beta ray gage and Huyck-Smyth porosity tester. Results obtained with the beta ray gage throughout the country were graphically illustrated; Mr. Berggren also outlined the advantages the instrument provides in measuring water removal efficiency at various presses. In explaining the operation of the Huyck-Smyth porosity tester, Mr. Berggren pointed out how the instrument locates filled and plugged streaks, determines the need for felt cleaning, evaluates the performance of cleaning equipment, and improves water removal.

John Skeer, Huyck staff assistant to the general superintendent, illustrated how paper machine requirements determine felt construction. By analyzing various types of machines and performance characteristics, Mr. Skeer explained the evolution in felts necessitated by modern, wider, faster machines. Drawing upon his more than 30 years experience in the application of felts to paper machines, Mr. Skeer was able to give specific examples of how much machine characteristics influence felt construction.

Romeo G. Cormier, superintendent, Gardiner Paper Mills, Gardiner, Me., recently earned the distinction of being the first and only papermaker to earn the "degree" of Master of Felt Technology by taking Huyck Felt Co.'s Felt Workshop course in Applied Felt Technology for the second time. Mr. Cormier was graduated from the eleventh workshop session held at Rensselaer, N. Y., in October of last year. According to a Huyck Felt Co. spokesman, the Gardiner Mill has made arrangements for all of its machine tenders to attend future workshop sessions.

The felt workshop is an intensified three-day course designed to familiarize papermakers with all important phases of felt application. A typical session covers such topics as "How felts are developed, design engineered, manufactured and serviced;" "The handling of felts in a paper mill;" "How Huyck research and development aid the manufacture of paper;" and "Trends of the future in machines and auxiliary equipment." Over 350 papermakers have either registered or completed the course.

Romeo G. Cormier, superintendent, Gardiner Paper Mills (r.), receiving his Master of Felt Technology "degree" from Bill Moe, vice-president and general superintendent, Huyck Felt Co. and Earl D. Rhodes, vice-president, Huyck Felt Co., and "Dean" of the Felt Workshops

Titanium Pigment

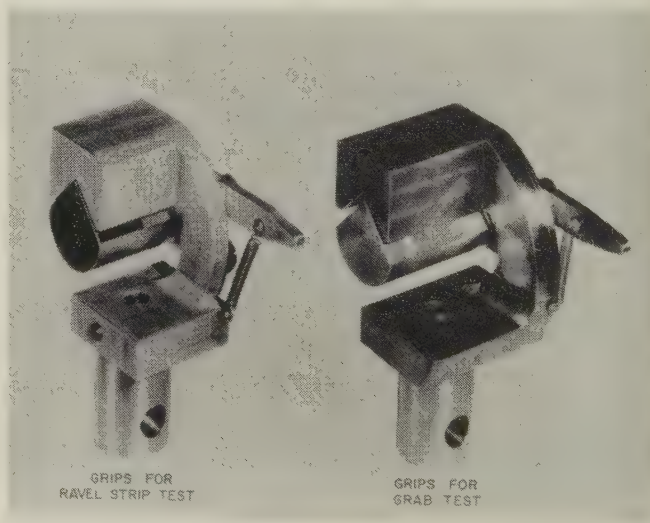
Titanium Pigment Corp., a subsidiary of National Lead Co., has announced the transfer of two sales representatives.

William H. Abels, a salesman in the New England sales district, has been transferred to the North Central sales district, with headquarters at Pittsburgh. John P. Burke will move to the New England sales district as a salesman. Mr. Burke's headquarters will be at Boston.

Thwing-Albert

The new self-tightening Capstan grips eliminate the problem of slippage in tensile strength testing of high strength textiles up to several thousand pounds, says Thwing-Albert.

The Capstan grips utilize the force exerted on the sample during the test as the source of clamping pressure for the grips. The Capstan grips, therefore, are excellent for high strength materials because the more force exerted on the sample the greater the holding power of the grips.



Capstan grips

The Capstan grips were developed by the Institute of Textile Technology at Charlottesville, Va., after a comprehensive study of the difficulties of gripping high tensile strength textiles for grab or ravel strip testing.

Capstan grips are made by the Thwing-Albert Instrument Co. at Penn St. and Pulaski Ave., Philadelphia 44, Pa.

Houghton

E. F. Houghton & Co., manufacturers of paper, textile, and metal processing products and specialized lubricants, is now serving Southern industry through its warehouse and office newly located in Carrollton, Ga.

Construction has been virtually completed on a new plant adjoining the present warehouse and office. This plant is served by the Central of Georgia Railroad, as well as by truck lines covering the South. The new plant was designed by Boroughs and Dale, Atlanta architects. The building construction is being done by W. O. Kilgore, general contractor of Carrollton, Ga.

Upon completion of the installation of manufacturing equipment, defoamers, wetting agents, detergents, warp sizes, finishes, lubricants, metal working, and heat treating products will be produced locally. These new integrated sales, warehousing, and manufacturing facilities represent the latest step in Houghton's expansion program to provide faster, more economical service to industry.

In addition to the new Carrollton plant and the main plant in Philadelphia, Houghton operates plants in Chicago, Detroit, Minneapolis, and San Francisco and in Toronto, Canada.

Southern Division sales are under the supervision of A. J. Andre who was formerly in charge of that operation at Charlotte, N. C.

Allis-Chalmers

Super-Seal open-type, drip-proof motors with epoxy resin insulation which is unaffected by moisture, dust, dirt, oils, acids, and alkalies, are facilitating operations at the American Box Board Co., Grand Rapids, Mich.

One motor, a 50-hp., 1750-r.p.m. machine, is powering a 6 by 5-in. Allis-Chalmers base-mounted pump on a cleaner. The other, a 25-hp., 1750-r.p.m. machine is mounted overhead on a 16 by 6-in. pump serving a slush maker. This arrangement permits use of the pump and motor in a limited space.

Two classes of new oil immersed, explosion-proof, corrosion-resistant, weather-proof, 2000-5000 v. starters designed for hazardous and semihazardous locations have been announced by Allis-Chalmers.

These NEMA Class EI starters are rated at 50-m.v.a. interrupting capacity and provide built-in short circuit protection to a motor on systems having a maximum of 50-m.v.a. capacity.

Copies of "Oil Immersed Squirrel Cage Motor Controllers," 14B8750, are available on request from Allis-Chalmers, Milwaukee 1, Wis.

This 50-hp., 1750-r.p.m. open-type, dripproof "Super-Seal" motor powering a 6 by 5-in. Allis-Chalmers base-mounted pump on a cleaner at the American Box Board Co., Grand Rapids, Mich., has an epoxy resin insulation which is unaffected by moisture, dust, dirt, oils, acids, and alkalies. It is designed for trouble-free operation under adverse atmospheric conditions

Westinghouse

A new booklet "Convenient Tables and Formulas" has been published by Westinghouse Electric Corp.

The book includes 120 pages of convenient tables, formulas, and graphical symbols summarizing electrical data, properties of materials, heat transfer and steam information, measurements, and other subjects.

For a copy of booklet B-3677D, call the nearest Westinghouse Apparatus Sales Office or write to Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

Gurley

The first catalog in a decade of "Precision Standards of Mass, Volume and Length" has been issued by W. & L. E. Gurley, Troy, N. Y. The bulletin includes a number of new classifications.

Gurley standards of volume are included in set of standards of weights and measures for Alaska presented to members of the new state's Congressional group at the Bureau of Standards by Lewis L. Strauss, Secretary of Commerce. From left, Senator Ernest Gruening, Strauss, Representative Ralph J. Rivers and Senator E. L. Bartlett. (Washington Post photo)

The 32-page illustrated bulletin will be of interest to officials responsible for standardization programs, as there are few domestic sources for precise standards of mass, volume, and length.

This spring, when Secretary of Commerce Lewis L. Strauss presented the first matched set of weights and measures to Alaska, the Gurley standards of volume from one gallon to one gill were among the equipment presented to officials of the 49th state.

The Gurley catalog includes new comparative weight tolerance charts and weights and measures reference tables. Copies of Bulletin 1500 are available from Weights and Measures Department, W. & L. E. Gurley, Troy, N. Y.

Appleton Machine

A "double barrel" log cutter, a fully automatic device for slicing long rolls of toilet tissue or toweling into household sizes, has been developed by Appleton Machine Co. The new double roll, double cut feature permits the machine to turn out twice as many small rolls—160 per minute—with the same number of strokes as any log cutter previously available.

The new cutter saws double sets of rolls simultaneously

Appleton Machine's new "double barrel" log cutter is demonstrated by Donald Woosencraft, project engineer. The new machine is twice as efficient as any log cutter previously available. The holes in the end of the push type-feeder are to accommodate projecting cores

from the ends of the logs. This is accomplished by a toothless band knife which actually makes four separate cuts—two on each roll—on the down stroke. Each forward movement of the push type feeder is nine inches as opposed to $4^1/_2$ in. found on single log cutters.

An added benefit of cutting rolls four-at-a-time at 9-in. intervals is the additional bite the clamping vice can achieve. The new log cutter clamps the parent roll for the full 9 in. and over 360°.

The new machine also features automatic self-sharpening of the band knife without down time.

Also available with the log cutter is a roll accumulator for automatically loading parent rolls onto the double barrel slides. For more information write Appleton Machine Co., Appleton, Wis.

Dominion Engineering

Robert P. Vaughan, P. Eng., has been appointed sales engineer in the Paper Division of Dominion Engineering Works, Ltd. He is a graduate of McGill in mechanical engineering and has returned to Dominion after an absence of several years.

Square D

A new 8-page bulletin describes the complete line of high-voltage starters manufactured by The Electric Controller & Mfg. Co., a division of Square D Co. For copies, write to The Electric Controller & Mfg. Co., Division of Square D Co., 4500 Lee Rd., Cleveland 28, Ohio. Ask for Bulletin 8130.

B. F. Nelson

The B. F. Nelson Mfg. Co. at Minneapolis, Minn., manufacturers and converters of folding boxboard, announces the recent installation and start-up of a Black-Clawson smoothing press and magnetic metering bar coater on their no. 1 paper machine.

Robert Gaven, manufacturing manager, stated that the use of this new equipment has greatly increased the smoothness, gloss, and printability of their boxboard.

The installation including the coating preparation system was engineered by The Black-Clawson Co., Dilts Division, Fulton, N. Y., and features its new patented magnetic metering bar coater, the first of its type to be put in production.

This coater is located in the paper machine section following the smooth press, and is applying approximately 2 lb. per 1000 sq. ft. with 45% solids.

The use of the magnetic metering bar holder provides a level and uniform surface on which the small bar rotates, and provides for easy removal of the rod. Commerical rods without special adapters or machining are utilized and can be changed rapidly.

The coater itself is of portable construction and can be moved out into the pending aisle for service and clean-up.

Bauer

Donald P. Michel has been appointed chief electronic engineer for The Bauer Brothers Co., Springfield, Ohio, manufacturers of a wide line of equipment for the pulp and paper industry.

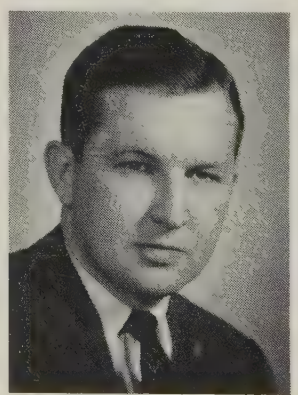
Minerals & Chemicals

G. A. Hale has been appointed manager of paper sales of Minerals & Chemicals Corp. of America, Menlo Park, N. J., effective March 1, 1959, it was announced by A. G. Blake, executive vice-president.

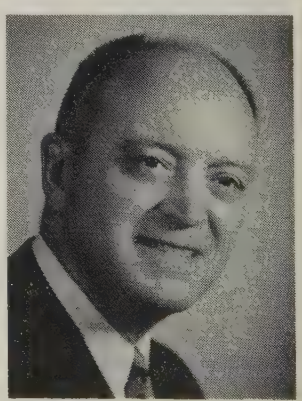
O. W. Callighan has been named to fill a new position at Minerals & Chemicals Corp. of America, Menlo Park, N. J. Effective March 1, 1959, Mr. Callighan will become director of customer relations, it was announced by A. G. Blake, executive vice-president.

R. P. Vaughan, Dominion Engineering Works, Ltd.

D. P. Michel, The Bauer Bros. Co.



G. A. Hale, Minerals & Chemicals Corp. of America



O. W. Callighan, Minerals & Chemicals Corp. of America

STALEY

Creation of a new process service section in the manufacturing division of the A. E. Staley Manufacturing Co. has been announced by General Superintendent William B. Bishop with several resulting administrative changes.

Named to head the new section as manager of process service is Edward B. Freyfogle, promoted from the position of syrup refinery superintendent.

E. B. Freyfogle, A. E. Staley Mfg. Co.

Mr. Bishop said the new section will develop and service special processing equipment for the company and for Staley customers. Examples of this type of equipment are jet cookers and high-temperature converters developed by Staley's for use in applications of Staley products in the paper, textile, and food industries.

The new section will be part of the process engineering department, headed by G. James Dustin, technical superintendent.

Creation of the new process service section will permit Staley Technical Consultant Oliver R. Etheridge, developer of the jet cooker, the high-temperature converter, and other process equipment, to resume full-time activity as technical consultant.

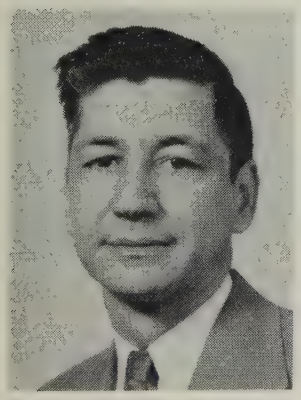
Named to succeed Freyfogle as syrup refinery superintendent is Paul L. Woijeck, who has been terminal elevator superintendent. Marion B. Foley succeeds Woijeck as terminal elevator superintendent, and Eugene A. Tiernan succeeds Mr. Foley as general foreman of the glutamate plant. Mr. Tiernan has been supervisor of manufacturing supplies.

Appointment of Leo A. Willoughby to a newly created position of coating supervisor in its field sales organization serving the paper industry has been announced by the A. E. Staley Manufacturing Co., Decatur Ill., corn and soybean processor.

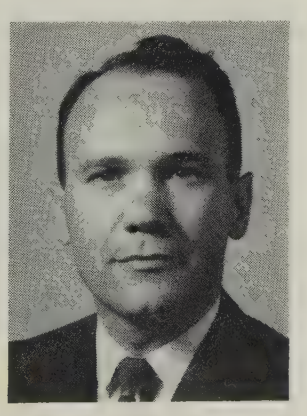
Robert L. Schuerman, manager of the company's paper industry sales, said Mr. Willoughby will continue as sales representative in Upper Michigan, Wisconsin, and Minnesota, but will aid other Staley representatives, customers and the company's paper applications research laboratory in technical service and consulting work as coating supervisor.

LODDING

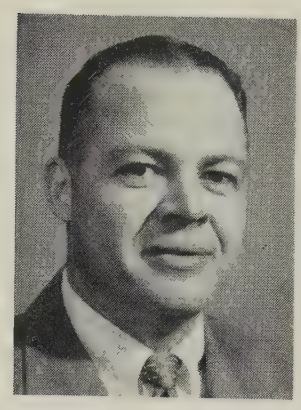
Lodding Engineering Corp., formerly located in Worcester, Mass., has completed the move to its new, 65,000 sq. ft. plant in the industrial park at Auburn, just south of the Worcester city line.



P. L. Woijeck, A. E. Staley Mfg. Co.



M. B. Foley, A. E. Staley Mfg. Co.



E. A. Tiernan, A. E. Staley Mfg. Co.

L. A. Willoughby, A. E. Staley Mfg. Co.

The new home of Lodding Engineering provides nearly double the manufacturing floor space available at their old 73 Beacon St. address.

A unique feature in industrial plant design is a 50 by 75 ft. garden courtyard, landscaped with trees, shrubs, and flowers. Offices, the reception area, engineering rooms, and employee lounges look out onto the open courtyard. This contributes to an inspiring and relaxing atmosphere in which to work.

The manufacturing area contains two 40-ft. bays and one 50-ft. bay, each 390 ft. long, and is flooded with daylight from fiberglass windows on all four sides, and a fiberglass skylight running the full length of the roof peak.

Timed with the move to their new facilities was Lodding's installation of a new planer. Of Italian manufacture, the planer (one of the longest in use in the country) has a 79-ft. base, a 36-ft. table, with a 4 by 4 ft. opening.

Lodding Engineering Corp. manufactures doctors, shower pipes, fuzz removers, water boxes, hydraulic oscillation equipment, and other specialized precision equipment used in the pulp and paper industry. Since Lodding was founded in 1929, the company has a record of steady growth. Besides enjoying national distribution, the company has licensed manufacturers of its products in Canada, France, and England.

KOPPERS

Koppers Co., Inc., with headquarters at Pittsburgh, Pa., has completed purchase of all assets of George W. Swift, Jr., Inc., Bordentown manufacturer of special machinery for the paper box industry.

Under terms of the agreement signed following a meeting of the Swift stockholders at which such action was approved, Koppers takes over all assets of the 68-year-old firm, exclusive of stocks and bonds which Swift own.

Negotiations for the sale have been going on for many months. The purchase price was not disclosed, but the transaction was in cash.

Koppers Co., which now has 71 plants in 29 states, will assign the Bordentown plant to its Metal Products Division, which has headquarters in Baltimore, Md. This division already makes printer-slotters and other equipment for the corrugated paper box industry.

H. B. Cummings, vice-president and general manager of the Koppers division, made the following statement:

"Acquisition of the well-known Swift Co. enables Koppers to offer complete corrugating systems to the paper box industry. The Swift line has an excellent reputation in this industry and the company has had many (firsts) in the paper working machinery field.

"Koppers intends to assume ownership of the Bordentown plant with a minimum of change to its present operation. Francis W. Overton, who has been president and

secretary of Swift will join Koppers in a consulting capacity. Other personnel of Swift, including its key people, also are expected to join the Koppers organization. Koppers nationwide organization will make every effort to increase sales of products from this plant and it is hoped that eventually we will have need for additional employees."

Currently the plant employs about 175 persons. Sales of the plant in 1958 totaled about $3,000,000.

F. M. C.

Carl F. Prutton, executive vice-president of the Chemical Divisions of Food Machinery and Chemical Corp., has announced the start of construction of a major addition to the Central Chemical Research Laboratory at Princeton, N. J. The expansion, in the form of a new wing, will add more than 50% to the laboratory floor space. Slated for use in February, 1960, the new section will cost around $1,000,000.

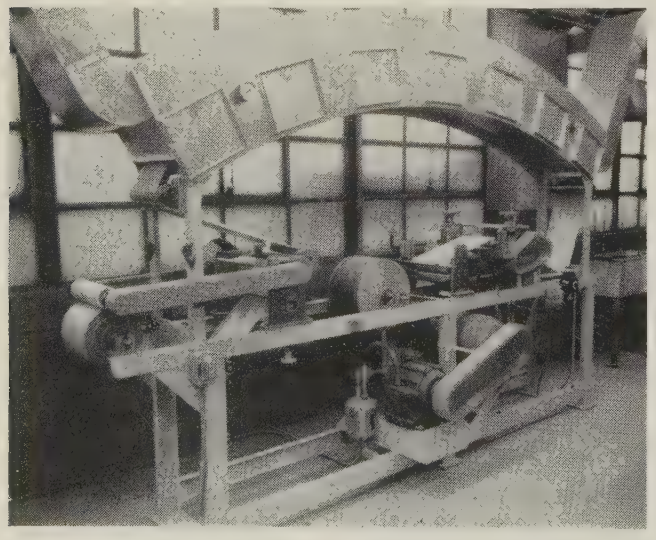
Mr. Prutton stated that the recently formed Inorganic Chemicals Research and Development Department, under the direction of Hans O. Kauffmann, will occupy most of the new wing, using it to increase product application and sales-service activities. Mr. Kauffmann's group includes the research staffs formerly associated with Becco Chemical Div., Westvaco Chlor-Alkali Div., and Westvaco Mineral Products Div. FMC's Organic Chemicals Research and Development Department, including Niagara Chemical Div. and Chemicals and Plastics Div., are under the direction of O. H. Johnson.

The staff of FMC's Princeton laboratory will be increased from its present level of 150 to about 200 when the new wing is completed, and is expected to go to 250 a year or so thereafter.

Stein, Hall

Stein, Hall & Co., Inc., announces an important addition to its extensive adhesive research and development facilities with the installation of a paper gumming, coating and laminating machine in the company's Long Island City laboratories.

The company is expanding its program on remoistenable, heat sealable, barrier, hot melt, and other specialty coatings through the use of this new equipment. Laminating experiments will also be scheduled and a large scale program is planned for developing specialty adhesives in this field.



The adhesive research and development laboratories of Stein, Hall & Co., Inc. are using this paper gumming, coating and laminating machine for producing adhesive products suitable for commercial evaluation

The machine is patterned on standard commercial coating and gumming equipment and can process a 10 in. web. Actual paper converting plant conditions are duplicated and products produced are suitable for commercial evaluation.

Ross Midwest Fulton

Ross Midwest Fulton, Dayton, Ohio, has announced the publication of Bulletin T-300 on Ross-Miami Steam Traps. Copies of Bulletin T-300 and other bulletins on the Cowie scraper, drier drainage systems, sight flow indicators, and hydroscillators can be obtained by writing to: Ross Midwest Fulton, Subsidiary of Midland-Ross Corp., 918 Woodley Rd., Dayton 1, Ohio.

A new, six-page bulletin describing the operation of Cowie scrapers and steam seals is now available from Ross Midwest Fulton, Dayton, Ohio. Copies of Bulletin CS-200 can be requested from Ross Midwest Fulton, Subsidiary of Midland-Ross Corp., 918 Woodley Rd., Dayton 1, Ohio.

National Starch

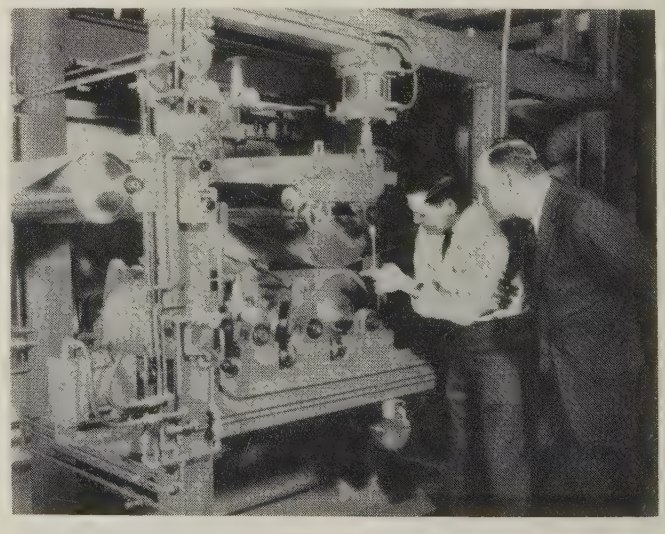
Differences between full-scale paper finishing and operations simulated in the laboratory to test coating and sizing materials prior to mill use were reduced to a matter of inches today as National Starch and Chemical Corp. researchers began work with a new pilot paper coater that has been installed here at the company's Alexander Research Labs.

National said its new coater is the largest and most elaborate piece of experimental equipment ever acquired for its laboratory. It required the construction of special housing facilities.

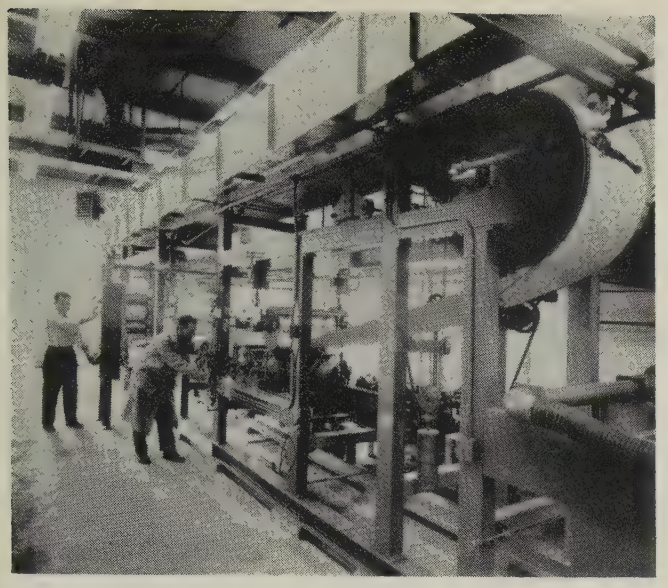
The company also expressed assurance that this is the fastest, most versatile and accurate coating machine to be installed for experimental work by any supplier to the coating industry.

Basically similar to full-size mill equipment except in roll width, the machine is capable of coating, drying, and calendering (both super or machine) in one continuous operation. It can also be set up to calender independently of the coating and drying stages.

National reported that its coater is 45 ft. long, $10^1/_2$ ft. high, and can run 22-in. wide paper rolls through its various stations at speeds up to 2,000 f.p.m. It was engineered to



Shown here discussing coating-head operations at National Starch and Chemical Corp.'s new paper coating machine are Leonard Wood (right), technical manager of Paper Development & Service, and Jerry Kronfeld, coating chemist. Set up in this picture for KCM coating process, the new equipment will enable National to perform all major types of paper coating and sizing operations right in its own laboratories



Full length view of new paper coating machine installed by National Starch and Chemical Corp.'s research laboratories gives some idea as to size and complexity of this equipment. Apparatus in foreground (partially obscured) is air hose leading to air knife coating apparatus. Large drum (top, forward) is 1200-lb. steam heated drier drum leading paper into overhead drier tunnel which runs full 45-ft length of machine. Laboratory technician, R. Eodice (center in coat) is shown checking pressure exerted by top coating roll while D. S. Greif, Supervisor of coating applications stands ready at main control panel. Machine is capable of running 22-in. wide paper stock at speeds of 2000-plus f.p.m.

National's specifications by the Wheeler Roll Co. of Kalamazoo, Mich.

The coater will do all six major types of coating and sizing processes as they are performed by the latest mill equipment. These operations are air knife, trailing blade, roll, reverse roll, size press, and modified size press. The company said also that it plans in the near future to add rolls for gravure and offset gravure coating.

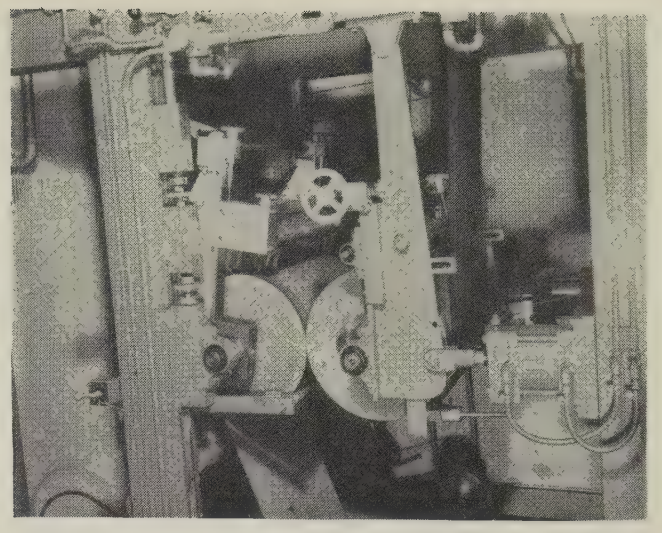
According to Leonard Wood, technical manager of paper development and service, the installation of such apparatus was made imperative by the growing complexity of modern paper finishing. "Bench tests for determining the machining characteristics of a starch or synthetic resin material are inadequate," he said, "and do not necessarily insure paper producers that the materials will react in full-scale production the same way they did in the laboratory.

"Our coater will be used primarily as a research tool," he said. "However it will also have important utility in specific customer service activities.

"Because the coater is so much like regular mill equipment," Wood explained, "we now have a means of simulating actual plant operations with a high degree of accuracy. This gives us a decided advantage in exposing newly formulated materials to conditions under which they will have to perform to complete customer satisfaction. We will no longer have to ask the paper mills to do this final experimental stage for us.

The net effect, Wood said, will be better, more economical coating and sizing and a needed reduction in the time required to evaluate new materials after they have emerged from the formulation and bench test stage.

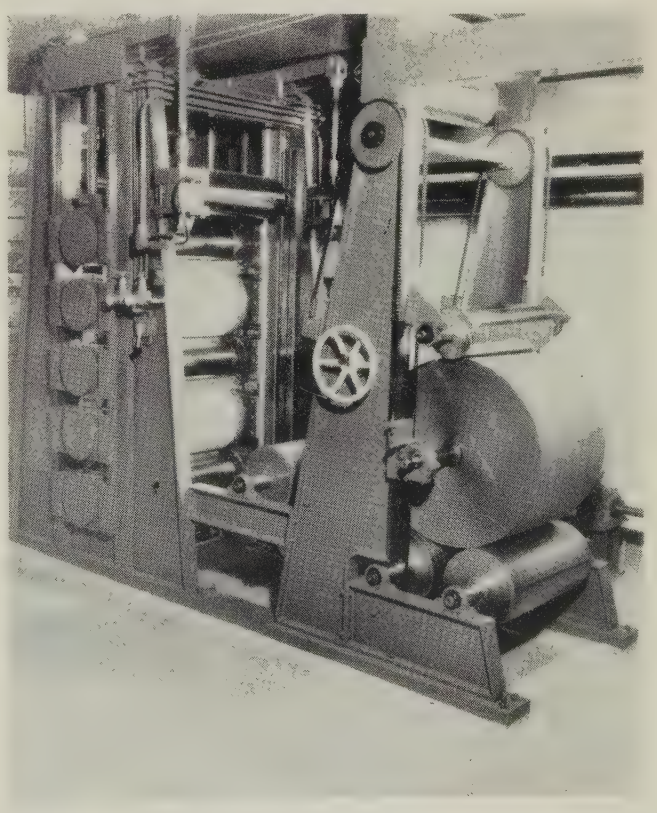
He said, too, that by simulating customers' operations in National's own laboratories the machine will help eliminate costly delays and waste often encountered when materials are introduced to mill equipment for the first time. "We will be better able," he said, "to select what is theoretically the best product for a customer's specific need and then test it adequately in our own lab before making a final recommendation."



Trailing blade coating equipment

Another important way in which National believes the coater will be valuable both to itself and the paper industry is in the study of still unexplained variables that contribute to the unpredictable nature of paper production. Since the coater will be run under laboratory control conditions, it will be possible to isolate many of these factors, National said, and publish the added knowledge where it will be of benefit to all.

As an example of the type research the coater will expedite, the company pointed to tests for printability. For the first time, National explained, it will be able to prepare large enough quantities of its own coated stock to determine how various materials react to inks and printing plate pressures under actual commercial printing conditions.



Calender stack (rear, left) and rewind

Other research investigations in which the coater will play an integral part were said to include the following: development of new and improved water resistant binder systems; development of light weight coating methods for publication papers; research on cationic starches for coating binders; development of resin materials for functional coating purposes such as high grease-proofness and low MVTR; new and improved methods of coating with standard binders.

Atlantic Refining

The Atlantic Refining Co. has unveiled one of the world's largest paraffin wax manufacturing plants at its Philadelphia refinery. Built at a cost of $18,000,000, including auxiliary facilities, the new plant will increase Atlantic's paraffin wax production capacity by more than 80%.

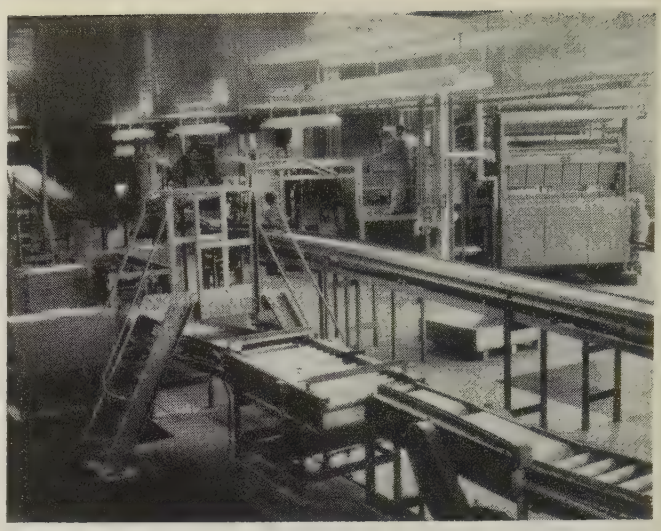
Designed and built by the Badger Manufacturing Co. of Cambridge, Mass., the plant employs the methyl ethyl ketone solvent dewaxing process. It covers an area of more than 4 acres and has a daily output of approximately 265 tons of wax. Supplementing this plant is a new automatic molding machine capable of forming wax slabs at a rate of 15,000 lb. New mechanized palletizing and packaging operations have completely eliminated manual handling of the wax.

The plant has a charge stock capacity ranging from 8000 to 15,000 barrels per day, depending upon the type of wax distillate being run. The power and heat requirements of the plant are equivalent to those of a city with a population of 40,000, and the refrigeration system could turn out over 4000 lb. of ice per min.

This new installation is another milestone in Atlantic's long history as a leading manufacturer of petroleum waxes. The company first began making wax in 1876 and has since pioneered many important advances in wax technology, including the first successful wax expressly manufactured for milk cartons. The new plant will increase Atlantic's supply of paraffin wax for manufacturers of such products as candles, crayons, phonograph records, explosives, and a variety of food wrappers and containers. Atlantic also manufactures a line of high melting point of microcrystalline waxes in another plant completed at the Philadelphia refinery in 1948.

In the new plant special wax distillates are mixed with a solvent and chilled to about 10°F. in power-driven scraper exchangers and chillers where the wax is crystallized out. This cold wax-oil-solvent mix then is fed to a battery of rotary vacuum filters where the liquid is drawn through canvas-covered drums and the wax slurry is retained on the canvas.

Atlantic's new multimillion dollar paraffin wax manufacturing plant. Employing the methyl ethyl ketone solvent dewaxing process, this plant has an output of 265 tons of wax per day. In the left foreground are the scraper-chillers; right foreground—filter house; center foreground—control room; background—furnaces and fractionating towers



Fifteen thousand pounds of wax slabs can be turned out each hour by Atlantic's new molding and packaging operation. Automatic from start to finish, this equipment completely eliminates any manual handling of the product

The wax on the drum is washed with additional solvent and continuously removed. The oil-solvent mix that is drawn through the filter is stripped in the solvent recovery section and the oil is sent to paraffin oil finishing or to cracking. The wax slurry goes through repulping and refractionating operations for further removal of oil and any other undesirable components still remaining.

In the final step known as finishing, the wax is subject to acid treatment and filtering through beds of diatomaceous clay to produce a fully refined wax. Special blending can be performed subsequently to meet specific end-use requirements.

OBITUARY

Robert D. Rusch

Robert D. Rusch, Manager of The Chase Bag Co. paper mill at Chagrin Falls, Ohio, died of a heart attack on May 6, 1959, at his home in Chagrin Falls.

Mr. Rusch was born in Neenah, Wis., on Oct. 27, 1907, and received his master's degree from The Institute of Paper Chemistry in 1934.

He was employed first by the Kimberly-Clark Corp., Neenah, Wis., as a research chemist after graduating from Lawrence College. In 1937 he became paper mill superintendent for The International Paper Co., Ft. Edward, N. Y. In 1942 and 1943 he was a test engineer for Scintilla Magneto Division. In 1943 he became technical superintendent for The International Paper Co. at N. Tonawanda, N. Y. In 1951 he became paper mill superintendent for the Mosinee Paper Mills Co., Mosinee, Wis., and in 1957 he became manager of The Chase Bag Co.

Mr. Rusch became a member of the Technical Association of the Pulp and Paper Industry in 1934.

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Corrosion Committee

On Feb. 23, 1959, a short impromptu meeting was held by the following committee members to go over the agenda for the main luncheon meeting on February 25: E. W. Hopper, H. W. Fritts, S. J. Baisch, C. W. Smith, F. Morrison, R. A. Davis, W. Boyd, and J. M. Wilcox. Mr. Hopper outlined briefly some of his thoughts in connection with the reorganization and reactivation of the Corrosion Committee. A few comments were made on possible mill representatives for the Corrosion Committee and also the need for a revision of some of the data sheets under the jurisdiction of the Corrosion Committee.

Luncheon Meeting

Members and guests attending the meeting were:

Members:

S. J. Baisch, Consultant
Z. S. Blanchard, Portland Co.
P. K. Block, Branson Instruments, Inc.
W. Boyd, Battelle Memorial Institute
H. M. Canavan, Mutual Boiler & Machinery Ins. Co.
H. W. Fritts, Aluminum Co. of America
E. W. Hopper, Consultant
D. Innes, International Paper Co.
L. K. Keay, Lukens Steel Co.
A. R. Meyer, Graver Tank & Mfg. Co.
F. Morrison, Penobscot Fibre Co.
J. B. Morrison, Crucible Steel Co.
W. B. Parker, Hartford Steam Boiler Ins. Co.
W. A. Rodowski, Consultant
J. A. Rogers, Oxford Paper Co.
C. W. Smith, Inland Container Corp.
D. T. Smith, Jessop Steel Co.
B. Thomas, Stebbins Engr. & Mfg. Co.
A. Tirado, Domicilio: Fabrica Celulosa
J. M. Wilcox, Electric Steel Foundry Co.

Guests:

A. O. Caldwell, Service & Erection Co.
R. Gackenbach, American Cyanamid Co.
P. J. Gegner, Columbia-Southern Chemical Corp.
G. Gerstacker, National Annealing Box Co.
J. T. Herlihy, Sandusky Foundry & Machine
W. B. Hogg, Hayden Wire Co. (representing Charles W. Hayden)
M. Mitchell, Chicago Bridge & Iron Co. (representing R. A. Davis)
H. O. Teeple, TAPPI

The meeting was officially opened by Mr. Hopper, chairman, after the luncheon was completed.

The minutes of the Portland meeting were reviewed. The Corrosion Committee did not hold a formal meeting during the 13th Engineering Conference in Portland, although the following four papers were presented under the sponsorship of the Corrosion Committee:

"Development of Anodic Protection for Application to Alkaline Pulping Digesters," by Walter A. Mueller
"Experiences in Evaporator Corrosion," by H. E. Jacoby and H. G. Lankenau
"Corrosion Test Experience in Pulp Bleaching Processes," by J. E. Wilkinson
"Controlling Corrosion in a Modern Magnesia Base Sulphite Mill," by J. E. Finsen

The authors of two of these papers, namely, Mr. Mueller and Mr. Wilkinson, are members of the Corrosion Committee.

As a report on the present status of the committee, the chairman pointed out that for all intents and purposes there had been no activity on the part of the committee or committee members on committee activities over the past year or so. The chairman also pointed out that the committee does not presently have a vice-chairman. A selection for this office will be made in due time.

Mr. Hopper, in pointing out the need for committee members who are willing, able, and have the time to participate in committee affairs, reviewed the TAPPI Manual outlining member obligations, duties of chairman, duties of members, and procedures for becoming a member. Mr. Teeple, TAPPI Technical Associate and former committee secretary, commented that it would be most desirable in re-establishing committee membership to maintain a balance from the pulp and paper industry and allied industry members. He also reviewed briefly the organization of a typical TAPPI committee.

Mr. Hopper emphasized that the scope of the TAPPI Corrosion Committee as established at the time the Committee was formed has to do with all matters in the pulp and paper industry relating to the corrosion of materials of construction. Five subcommittees have been established:

1. Alkaline Pulping
2. Acid Pulping
3. Neutral Sulphite Pulping
4. Pulp Purification
5. Miscellaneous

The first order of business in connection with the subcommittee will be to secure officers for the subcommittees, and then to ask the committee members to align themselves with one of the subcommittees in accordance with their desires.

On the subject of project discussion, the following items were covered:

1. Data sheets—Mr. Hopper pointed out that a number of the data sheets which are assigned to the jurisdiction of the Corrosion Committee are in need of review, revision, or deletion.
2. In connection with the forthcoming 14th Engineering Conference to be held in Pittsburgh, Pa., Oct. 12 through 15, 1959, the committee would like to sponsor three or four technical papers. Committee members who have or can prepare suitable papers or know of other persons with suitable papers are urged to make the information available to Mr. Hopper.
3. Mr. Hopper commented that it should be the future desire of the committee to get together all possible information and ultimately publish a handbook on materials of construction in the pulp and paper industry. Because of the vast area which would be covered in such a handbook, this project presents a real challenge to the Corrosion Committee.

Mr. Hopper continued the meeting by inviting various committee members to report on problems they encountered in their own mills or to suggest problems which they knew about which might be of interest to the TAPPI Corrosion Committee.

Mr. Rogers, Oxford Paper Co., pointed out the problem often encountered in the corrosion of stacks. A number of other mills have similar problems so this might well be a

good problem for the TAPPI Corrosion Committee to tackle.

Mr. Morrison, Penobscot, mentioned his continuing interest in the cathodic protection of digesters and also pointed out a problem that he has encountered in the corrosion of evaporator tubes and in equipment handling chlorine dioxide bleach liquors.

Mr. Smith, Inland Paper, commented that the evaporator tube corrosion problem often is solved by changing the tubes (questionable solution). He also pointed out the trend to outdoor construction in the pulp and paper industry, particularly in the South, and suggested this subject for a paper on protection and shielding of equipment installed in outdoor plants. It was noted that this subject might be of particular interest to the 1960 Engineering Conference, which will be held at Jacksonville.

Mr. Innes, Southern Kraft Division, International Paper, reported his company had run into all the various corrosion problems inherent in kraft pulping and bleaching operations. He suggested that perhaps the best way to solve some of the troublesome problems would be to divide the Committee into smaller groups. (*Note:* This suggestion, to some degree, is in line with the subcommittee structure of the Corrosion Committee.) Mr. Innes pointed out the ever important problems of maintaining production and the need to sell pulp and paper mill management on a corrosion prevention program.

Mr. Tirado, Fabrica Cellulosa, mentioned that his company was concerned with a problem involving the deterioration of concrete stacks handling hot, salt-laden gases. Apparently the salts were crystallizing in the pores of the concrete and causing spalling.

Mr. Hopper commented that in many respects the TAPPI Corrosion Committee and NACE (National Association of Corrosion Engineers) were striving toward the solution of similar problems and that the two organizations might offer outlets for each other's papers.

Mr. Boyd, a new member from Battelle Memorial Institute, pointed out that a research organization, as Battelle, was very interested and able to cope with corrosion problems in the pulp and paper industry.

Mr. Gackenbach, American Cyanamid Co., who visited the meeting, indicated that many of the corrosion problems encountered in the pulp and paper industry have their counterpart in the chemical industry and he suggested that solutions to corrosion problems found in one area might be helpful in another.

M. Canavan, Mutual Boiler & Machinery Insurance Company, presented a summary of the current status of Alkaline Digester Corrosion as reported by the National Digester Group. Limited copies of the report were made available to those at the meeting who were interested in this information.

The 1958 supplement, "A Bibliography of Alkaline Digester Corrosion," prepared by R. B. Kesler of The Institute of Paper Chemistry, also was distributed at this meeting. Copies of this paper are available from the secretary.

Mr. Wilcox, Electric Steel Foundry, pointed out the ever pressing need for publicity to get information on the results of Corrosion Committee work to the attention of the pulp and paper industry. A suggestion was made that we have a publicity chairman. Mr. Hopper asked Mr. Wilcox if he would take on this job. A decision is pending.

A suggestion also was made that if committee members and pulp and paper industry representatives would submit details of any of their corrosion problems to the secretary or chairman of the Corrosion Committee, immediate attempts would be made to get together whatever information is available and pass it along. By solicitation of information from present members, many corrosion problems might find at least a partial solution. The submission of corrosion questions by the industry also might serve as a guide for additional Corrosion Committee projects.

Data Sheets Committee

H. G. Ingraham, Chas. T. Main, Inc., Boston, Mass. chairman, opened the meeting at 3:04 p.m. by introducing the following people and indicating the committee each person represented:

A. Chase, Chemical Engineering
A. W. Plummer, Chemical Engineering
W. Pittam, Civil Engineering
E. W. Hopper, Corrosion
H. W. Stevens, Drying
I. H. Witham, Electrical Engineering
G. W. Sargent, Jr., Engineering Economics
F. Holmes, Engineering Economics
C. A. Lee, Fluid Mechanics
D. D. Hall, Industrial Engineering & Materials Handling
H. F. Parker, Industrial Engineering & Materials Handling
P. H. Goldsmith, Mechanical Engineering
J. S. Mudgett, Mechanical Engineering
J. K. Powall, Process Instrumentation
W. A. Moggio, Sanitary Engineering
J. G. Hoad, Steam and Power
P. L. Nelson, Steam and Power
E. H. Olmstead, Staff Advisory
H. O. Teeple, Secretary

The reading of the minutes of the Portland meeting of the committee was dispensed with because of the absence of the secretary who was delayed. Mr. Pittam was asked to make notes until the secretary arrived.

Mr. Ingraham inquired if everyone had copies of the following material which the secretary distributed by mail prior to the meeting:

a. Meeting agenda
b. Engineering Division Administrative Policy No. 13
c. Engineering Data Handbook Outline
d. Committee assignments for review of existing data sheets
e. Committee assignments for review of data sheets in process

Chairman Ingraham asked for a discussion of the phrase "In general, engineering data (for Data Sheets) will not be readily available from other sources" and its application in the matter of acquiring data sheets. After lengthy discussion, it was agreed a liberal interpretation of the phrase would be appropriate at this time.

Mr. Ingraham asked the representative of each Engineering Division committee present to report on the status of the following items:

a. Review of existing data sheets
b. Review of data sheets in process
c. New data sheets
d. Deadline dates re (a), (b), and (c) above

Chemical Engineering

Some action has been taken i.e., eight have been submitted for review, four have been revised and submitted, two not listed have been submitted, one has been proposed for discarding. In summary, 28 new ones have been prepared and of these 24 have been published.

Civil Engineering

The two existing data sheets assigned to this committee are being reviewed and a report will be submitted later.

Corrosion

The one existing data sheet assigned to this committee is being reviewed and is probably in need of substantial revision.

Drying

The existing data sheets assigned are being reviewed and the committee has a project established to correlate CPPA Technical Section Data Sheets with those of this committee re handbook outline.

Electrical Engineering

This committee has eight projects underway which should result in data sheets. Three data sheets in process have been submitted for review and four revised existing data sheets have been submitted for review.

Engineering Economics

Primarily because of the new offices of this committee, no progress can be reported at this time. The committee has two projects underway which should lead to data sheets.

Fluid Mechanics

Fifteen existing data sheets have been distributed to the committee for review but no reports are available at present. It was pointed out the projects currently underway should develop data sheets.

Industrial Engineering and Materials Handling

It was reported five Data Sheets are in process and nine have been submitted for review.

Maintenance Engineering

Because of the absence of a representative of this committee, no report was available.

Mechanical Engineering

It was reported the current committee program should develop data sheets. None is reported in progress. A data sheet is desirable for vacuum requirements at the wet end of the machine.

Process Instrumentation

The data sheets assigned to this committee will be considered at the interim meeting of the committee.

Sanitary Engineering

The data sheet assigned to this committee will be reviewed at the next meeting of the committee. Some data sheets appropriate to this committee are presently assigned to the Chemical Engineering Committee. It was suggested these data sheets be reassigned to the Sanitary Engineering Committee. This was done.

Steam and Power

Some of the data sheets assigned to this committee have been reviewed. As a result it was suggested that No. 117 be cancelled since its merit is highly questionable. With respect to "usage" of steam and power, it was pointed out data sheets were difficult to define but progress was reported.

Chairman Ingraham thanked each one for his report and then raised the question of the necessity or desirability of an interim meeting of the committee.

After substantial discussion it was decided no interim meeting would be held but that a written report of data sheet activities by each committee, due June 1, would be substituted for the meeting. The committee would continue to meet in February at the Annual Meeting and in the fall at the Engineering Division Conference. A reminder for the report would be distributed about May 1.

Under the category of new business, the index and list of titles of CPPA Technical Section Data Sheet was distributed to each committee represented. The suggestion was made that if a committee felt the CPPA Technical Section Data Sheet would be of value as a TAPPI Data Sheet, copies of the data sheet would be procured through appropriate channels for review by the committee.

The meeting was adjourned at 5:00 p.m.

H. O. Teeple, *Secretary*

Fluid Mechanics Committee

The Subcommittee on Dilute Fiber Suspensions met at the Hydrodynamics Laboratory, M.I.T., Cambridge, Mass., on April 10, 1959.

The following were present:

Subcommittee Members:
S. G. Mason, *Chairman*
W. L. Ingmanson

Others:
C. A. Lee (Member, Fluid Mechanics Committee)
A. A. Robertson (Pulp & Paper Research Institute of Canada)
A. T. Ippen and J. W. Daily, M.I.T. Grantees, TAPPI Research Project No. 126
G. Bugliarello (Research Assistant, M.I.T.)
W. Troutman (Graduate Student, M.I.T.)

The meeting commenced at 10 a.m. and after preliminary discussion the group inspected the experimental facilities for measuring velocity profiles and turbulence in flowing pulp suspensions.

On resumption of discussions, Messrs. Daily and Ippen announced that Messrs. Bugliarello and Mr. Troutman would be completing their work during the summer and that it was intended to wind up work under TAPPI Research Project No. 126 by October 1, and that they had no plans for continuing the work beyond that date. This surprised the committee members present since there had been no previous suggestion that the work should terminate so soon. On further discussion, it appeared that Messrs. Daily and Ippen had the impression that the grant would not be renewed.

After some discussion from which it emerged that the grantees would be interested in continuing the work provided, of course, that TAPPI would renew the grant with the understanding that it continue for 2 years. This period of support is necessary since two new graduate students would be assigned to the problem for a 2-year period. It was stated, however, that some assurance would be required within the next couple of weeks in order to plan for new students to start work in September or October. The chairman, regretting the unavoidable absence of Mr. Shoumatoff, undertook to telephone him as soon as possible to inform him of this situation and to advise either Mr. Ippen or Mr. Daily as soon as possible what were the chances of renewal. If they appeared favorable, a new research proposal would be submitted.

Mr. Bugliarello then outlined his work on velocity profile measurements in some detail. These studies were described in the report entitled "The Effects of Fibers on Velocity Distribution," Technical Report No. 30, copies of which have been sent to chairman, Fluid Mechanics Committee. In addition reference was made to the following two reports:

1. "Flow of Nylon Fiber Suspensions," Technical Note No. 4, James W. Daily and A. Tsuchiya. February, 1959.
2. "A Particular Non-Newtonian Flow: Dilute Fiber Suspensions," James W. Daily and George Bugliarello.

The work on velocity profiles appears to be drawing to a successful conclusion and will be terminated with Mr. Bugliarello's departure from the laboratory in September.

Mr. Troutman then outlined his work on the measurement of turbulence by recording the pressure-noise on an Ampex recorder and subsequently performing an auto-correlation analysis by means of an electronic computer. The results look extremely promising but after lengthy discussion it became clear that additional work is necessary to establish unequivocally the effect of the fibers in damping the turbulence. If the grant were renewed, it is this phase of the work which would be emphasized in future experiments. It may be noted parenthetically that the equipment required for this work is very costly and is available free of charge to Mr. Daily.

After some discussion it was indicated by the committee that in any future studies it would be of interest to:

1. Extend the measurements of profiles and turbulence to tubes of larger diameter (above 2 in.) and in connection with

studying the onset of turbulence, to include studies of simpler particles such as rigid spheres.

2. Extend the measurements to flows in channels having flat surfaces in order to approximate more closely conditions in headboxes.

3. Conduct measurements at fiber concentrations in excess of the present upper limit of 1.0%.

The question of reporting the work to date in a form suitable for publication in *Tappi* was discussed. The subcommittee advised Mr. Daily to publish his results as two or three papers as distinct parts under the same general title. He was advised that if his grant were renewed, it would be better to withhold publication of some of the turbulence measurements until they could be repeated and confirmed. In the event that the grant was not renewed, Mr. Daily stated a preference for a single terminal report suitable for publication in *Tappi*. The subcommittee concurred.

The chairman took advantage of the occasion to outline some work being done by graduate students at the Pulp and Paper Research Institute of Canada on the behavior of particles in laminar shear and on the bursting and coalescence of fluid drops. These were illustrated by means of high speed cine photographs.

The meeting adjourned at 4:45 p.m.

Postscript

The chairman was unable to locate Mr. Shoumatoff by phone until April 15. After an exchange of calls:

Mr. Shoumatoff advised that the spring deadline date for applications for TAPPI research grants was April 1, and it was too late. The next time for considering grants was in October.

Mr. Shoumatoff agreed to phone Mr. Daily to urge him to submit an application for consideration in October.

Process Instrumentation Committee

The Process Instrumentation Committee met April 2, 1959, Pittsburgh, Pa. Those attending were:

J. K. Powell, *Chairman*
E. W. Prince, *Vice-Chairman*
R. D. Clarke, *Secretary*
C. S. Connor
C. W. Dawson
G. G. M. Eastwood
H. P. Fishwick
R. R. Gardner
L. G. Good
G. L. Harman
R. B. Hurm
D. J. Morrissey
R. H. Pentecost

R. T. Charters attended the meeting in the place of J. R. Lavigne. There was one visitor present:

H. O. Teeple, TAPPI, New York, N. Y.

The meeting was called to order by Chairman Powell, followed by self-introduction of all present.

Announcement was made of the change in secretary of the committee. Due to a change in job Harold Sholl has found it necessary to resign from the committee. R. D. Clarke will be the Minneapolis-Honeywell representative on the committee and will also serve as the new committee secretary. It was suggested by Horace Fishwick and approved by the Committee that a letter be sent to Harold Sholl expressing the appreciation of the committee for his work. The secretary will handle this matter.

Reading of the minutes of the previous meeting was dispensed with, since all members had received a copy of these minutes by mail.

Selection of All Subcommittee Chairmen

The areas to be covered by each of the subcommittees was thoroughly discussed and chairmen appointed by the committee chairman. The subcommittees are now set up as follows, with chairmen as shown:

Subcommittee	*Chairman*
1. Pulping	G. G. M. Eastwood
a. Chemical	
b. Washing	
c. Bleaching	
d. Screening	
e. Mechanical	
f. Wood Preparation	
2. Chemical Preparation and Recovery	R. R. Gardner
3. Pulp and Paper Machines and Stock Preparation	R. B. Hurm
4. Water Treatment; By-Products and Waste	R. H. Pentecost
5. Data Sheets	C. E. McCarty
6. Special Projects	Chairman will be named by committee chairman as needed

The chairman, with these appointments, also dissolved all previous subcommittees. He further pointed out the need for more active work on the part of subcommittee members. Subcommittee chairmen should get help from any members of the Process Instrumentation Committee.

The chairman also announced the formation of a steering committee composed of the committee officers and the chairman of the first four sub-committees listed.

Discussion of Proposed Projects

Further discussion was carried out on the proposed project, "The Principles of Paper Moisture Measuring System." This project was assigned by Chairman Powell to the Subcommittee on Pulp and Paper Machines and Stock Preparation.

After a discussion, a proposed project on magnetic flow meters was rejected due to limited scope. The committee will take under advisement a project on stock flow measurement.

Project No. 692 "Organization and Importance of the Paper Mill Instrument Department"

The committee vice-chairman presented a questionnaire to the committee. It was composed by the subcommittee and showed results of a great amount of work put into it. The subcommittee chairman was not in attendance and this was regretted since we missed the guidance of his thinking in preparing the questionnaire. Many suggestions were made at this point and this discussion was continued following the formal close of the meeting. The result was a number of suggestions which will be summarized by the chairman and forwarded to the subcommittee chairman as a guide for the final questionnaire. Mr. Teeple advised that TAPPI headquarters would mail the questionnaires and compile the data from returns.

Question-and-Answer Column in Tappi

Chairman Powell explained the purpose of the column and the need to get it properly started with interesting questions and answers. He is in need of additional material for this column now. Members are urged to submit questions and answers directly to the chairman.

Data Sheet Subcommittee Progress Report

A report was given on the meeting held by the Engineering Data Committee in New York in February. Chairman Powell represented this committee at that meeting. The over-all objective is to publish an Engineering Data Handbook. Further progress reports will be made by the committee members at meetings which will be held in February, June, and October of each year.

Data Sheets assigned to this committee were discussed. Three have been assigned to us and the following action was taken.

Data Sheet No. 129—Curves on "Discharge Through Sluice Gates."

Information on sheet by M. Jacobs, Chas. T. Main, Inc.
Mr. Dawson will check this with Mr. Jacobs and report to the chairman the accuracy of the data, whether they are still pertinent and the latest available.
Data Sheet No. 139—"Water Consumption and Fiber Losses."
This sheet will be returned to the Engineering Data Committee with our comment that it is not pertinent to our committee activity.
Data Sheet No. 158—"Pulpwood Losses."
No copy was available. Mr. Teeple will supply a copy to the chairman for comment.

It was recommended that the Data Sheet Subcommittee indicate to the Engineering Data Committee which other data sheets should be cross referenced to the committee.

Mr. Teeple advised of the availability of CPPA Data Sheets for the review of this committee for possible inclusion in our list.

ISA Relations

Louis Good is now the ISA Paper Industry Representative. He replaced Robert Spangler in this capacity. He suggested possible joint programs in the future, such as a Symposium on Paper Instrumentation. Another point suggested was petitioning of ISA Recommended Practices Committee for Data Sheets. Louis Good pointed out that ISA has accumulated a mailing list of 750 people with interest in Pulp and Paper Instrumentation.

Garnet Eastwood is program chairman for a proposed Paper Symposium by the Fox River Valley ISA Section to be held in the Spring of 1960.

Southeastern Regional ISA is reported to be considering a one or two-day paper meeting in Pensacola in May, 1960. Steering Committees of ISA and TAPPI should determine by October how the societies can cooperate on a meeting. In October, agreement should be reached on the extent to which each can work, with Louis Good handling ISA clearance and the chairman gaining TAPPI approval. Mr. Teeple offered to meet with ISA officials and stated TAPPI philosophy of conducting such meetings on a nonprofit basis.

14th Engineering Conference

This conference will be held October 11–15 at the Penn-Sheraton Hotel, in Pittsburgh, Pa. The program of this committee is scheduled for 9 to 12 a.m. on Tuesday, October 13. A luncheon was discussed and it was decided not to have one. The meeting of this committee is to be held at 6:00 p.m. Monday evening in Parlor B on the 17th floor of the Penn-Sheraton.

Two papers have been arranged for program as reported by Bob Hurm:

1. Experimental Recovery Unit. Bob Hurm will advise the correct title and author, along with company affiliation and location.
2. "A Versatile New Consistency Regulator," by K. I. Mumme and N. W. Swanson of Kimberly-Clark. The paper will be presented by Mr. Swanson.

The third paper will be on, "How One Mill Handles Instrumentation" (Engineering, Specifications, Applications, Maintenance). This will be presented by J. R. Upson, of Union Bag-Camp Paper Corp., or Jim Powell.

Future possibilities for papers were discussed as:

1. Stock preparation on Book Paper Machines by Mr. Dodds of International Paper Co.
2. United Kingdom Instrumentation
3. Beta Meters and Basis Weight
4. Consistency—Mr. Morrissey
5. Cloud Nine—Computers, Data Logging, etc.

The meeting was adjourned. The next meeting to be Monday, October 12, at 6:00 p.m. in Pittsburgh, Pa., at the Penn-Sheraton Hotel.

R. D. Clarke, *Secretary*

Forest Biology Committee

The second regular meeting of the TAPPI Forest Biology Committee was called to order at 9:08 a.m., Feb. 24, 1959, by Chairman Philip N. Joranson, in Parlor F of the Hotel Commodore, New York. Seventeen regular members of the committee, one alternate, and five visitors—a total of 23—attended the meeting.

F. C. Cesh, International Paper Co.
K. W. Dorman, Southeastern Forest Experiment Sta.
C. H. Driver, International Paper Co.
R. M. Echols, Southern Forest Experiment Sta.
E. Ellis, University of Michigan
L. A. Hiett, Buckeye Cellulose Corp.
B. A. Jayne, Washington State College
P. N. Joranson, The Institute of Paper Chemistry
P. T. Lannon, Jr., West Va. Pulp & Paper Co.
P. R. Larson, Lake States Forest Experiment Sta.
M. G. Lyon, Champion Paper & Fibre Co.
D. J. MacLaurin, The Institute of Paper Chemistry
F. Mergen, Yale University
H. L. Mitchell, Forest Products Laboratory
M. Reines, University of Georgia
S. H. Spurr, University of Michigan
E. P. Stephens, Champion Paper & Fibre Co.
E. Thorbjornsen, North Carolina State College
J. P. van Buijtenen, The Institute of Paper Chemistry
P. C. Wakeley, Southern Forest Experiment Sta.
L. C. Walker, National Plant Food Inst. and University of Georgia
P. R. Wheeler, Southern Forest Experiment Station
B. Zobel, North Carolina State College

After self-introductions of all present, the agenda distributed by the chairman February 11 and amended in the interim, was put in final form, as follows:

1. Notice of changes in membership.
2. Brief review of 1958 activities.
3. Note on activities of Forest Tree Improvement Committee of the Society of American Foresters.
4. Report of Subcommittee 1, on Bibliography.
5. Report of Subcommittee 2, on Tests and Quality Objectives.
6. Discussion of and action on suggestion that 1960 annual meeting of the committee be held in Seattle, just before the August 29 to September 10 World Forestry Congress.
7. Discussion of program and call for papers for 1960 meeting.
8. Statement of TAPPI Research Policy.
9. Research appropriation requests.
10. Other business, including basis for change of officers and specification of term of officers.

Mitchell moved that the reading of the minutes of the Feb. 18, 1958, meeting, which had been published on pages 156A–

Forest Biology Committee

158A of *Tappi* for August, 1958, be dispensed with. Driver seconded the motion, which was *carried* unanimously.

The chairman then summarized the news release sent out in the spring of 1958, and added the following more recent notes concerning committee members:

Charles Carpenter, private consultant, has accepted appointment on the committee.

Ben A. Jayne has transferred from the Yale School of Forestry to Washington State College.

Louis A. Hiett, Buckeye Cellulose Corp., is serving as alternate for F. E. Pollock during the present meeting.

Donald J. MacLaurin, Chief, Pulp and Papermaking Section, The Institute of Paper Chemistry, has accepted appointment on the committee.

Malcolm N. May has remained a member of the committee despite his move from The Institute of Paper Chemistry to the Gulf States Paper Corp. at Tuscaloosa, Ala.

Thomas O. Perry has accepted a year's postdoctoral National Science Fellowship at the California Institute of Technology.

Ted Youum, Simpson Logging Co., has been invited to join the committee.

Robert Zahner has transferred from the Southern Forest Experiment Station at Crossett, Ark., to the School of Forestry and Conservation, University of Michigan.

Robert Zabel has accepted appointment to the committee.

In connection with the committee memberships in general, the chairman reminded those present of the TAPPI rule that they might remain committee members for the first year without becoming members of TAPPI, but that at the end of the year they would be given "cordial—and firm—invitations to join TAPPI."

The chairman also announced, with regret and with much appreciation for his work, Wakeley's resignation as secretary of the committee, to become effective with completion of these minutes; discussion of its effect was referred to item 10 of the agenda.

Under item 2 of the agenda (1958 activities), it was noted that the February, 1958, session papers were published in full in the April, 1958, issue of *Tappi;* that both subcommittee projects had been approved by the parent organization; that suitable publicity had been sent out; and that Subcommittee No. 2, on Tests and Quality Objectives, had met in New York in July and had had the minutes of its meeting published in *Tappi* for October, 1958.

Under item 3, Tree Improvement Committee of the Society of American Foresters, Zobel, the past chairman of that committee, described its main job as liaison; its past meetings in connection with meetings of the Society have been either rather informal, or open get-togethers. It has sponsored the more recent of Jonathan W. Wright's annual forest genetics bibliographies and a biennial one listing 1956 and 1957 publications, and has prepared a glossary of the forest genetic terms, which is about to be issued by the Southern Forest Experiment Station. At the San Francisco meeting of the Society this coming fall, the society's committee will hold a panel discussion and open meeting on the pros and cons of selection in forest tree improvement. Zobel's successor as chairman of the society's committee is Richard T. Bingham, Northern Idaho Forest Genetics Center, Moscow, Idaho.

At Joranson's request, Wakeley and Spurr reported on last November's special genetics issue of the *Journal of Forestry,* and on *Forest Science,* respectively. Spurr said about 75% of the manuscripts submitted for *Forest Science* meet the rising standards of that periodical well enough to be accepted, and that there is no limitation as to type of article other than that it be of high scientific quality. Accepted articles up to 16 *Forest Science* pages are printed gratis. It is discretionary with the editors whether to charge for the 17th through the 32nd pages. Authors or their agencies must pay in full for articles more than 32 pages long, which will be issued (with 1000 copies to the author or agency) as separate monographs, paged as supplements to *Forest Science,* and sent without extra charge to all subscribers.

Under item 4 on the agenda, Larson, chairman of Subcommittee No. 1, on bibliography, read the report for that subcommittee.

Under item 5, Lannan, chairman of Subcommittee No. 2, on Testing and Quality Objectives, read the report for his subcommittee.

In discussing these subcommittee reports, Echols moved that hereafter, at annual meetings, the subcommittees meet before rather than after the parent committee. Ellis seconded this motion, which was *carried* unanimously.

Ellis asked what outlet was contemplated for the findings of the Subcommittee on Testing and Quality Objectives. The ensuing discussion, led by Driver, suggested that ultimately, though certainly not right away, the findings might result in the establishment of formal TAPPI testing standards, a possibility further elaborated by Lyon.

Mergen inquired whether TAPPI could negotiate a professional statistical evaluation of various tests (of wood characteristics, quality, and the like). No direct answer was forthcoming, but Mitchell pointed out that the Forest Products Laboratory, U. S. Forest Service, was actually making such analyses of values obtained from single increment cores as against 2, 3, and 4 core samples per tree.

After a 10-min. break at 10:40, the chairman introduced item 6 of the agenda, the possibility of a Seattle meeting at the time of the World Forestry Congress. After citing plans for the congress itself and numerous endorsements from western members of the committee of a meeting on the West Coast, he introduced Jack Winchester, Technical Associate, New York Office, who suggested a committee business meeting in New York in February, 1960, and a technical session at Seattle at the time of the Congress. Winchester said TAPPI would make the necessary hotel arrangements for the latter.

After a spirited general discussion, Wakeley moved that, in addition to a February, 1960, business meeting in New York, the TAPPI Forest Biology Committee hold a technical session, business meeting, possibly subcommittee meetings and a field trip either before or after the World Forestry Congress in Seattle Aug. 29 through Sept. 10, 1960. Mitchell seconded this motion, which was carried, 13 to 4.

It became obvious, in further discussion, that such a Seattle meeting would have to be held before the World Forestry Congress because of teaching assignments, the possibility of attendance in combination with family vacations, and the like. The pre-congress period was accepted without formal vote. Joranson appointed an interim committee, consisting of Zobel (chairman), Mitchell, MacLaurin, Bialkowsky, Yocum (as alternate for Seidl), and Winchester, to make any immediate decisions necessary in connection with the Seattle meeting. These decisions were to include consideration of the following appointments, to continue through the Seattle meeting:

Seidl, general chairman (assisted by Yocum)
Duffield, technical chairman
Callaham, local arrangements chairman
Richen, publicity chairman
Bialkowsky
Ex-officio: Chairman of TAPPI Forest Biology Committee; Secretary of TAPPI Forest Biology Committee

Under item 7, Joranson suggested that a compilation of tests applicable to nondestructive samples, unearthed or devised by Subcommittee No. 2, might furnish substantial material for the Seattle technical session. This was tacitly referred to the technical chairman for the Seattle meeting.

Under items 8 and 9 of the agenda, Joranson asked Winchester to explain TAPPI research policy. In so doing, Winchester summarized briefly pages 44–45 of the 1958–59 TAPPI Yearbook on this subject, and promised to send reprints of these pages to all committee and subcommittee members. Research appropriation requests are considered on

April 1 and October 1 each year. None have been made by the TAPPI Forest Biology Committee or are being made at the present meeting, although Subcommittee No. 1 on Bibliography, received an executive grant of $100 in 1958, for needle sort bibliography cards.

Under item 10, the chairman reiterated the fact that Wakeley was resigning as secretary, and Wakeley explained that this was necessary because of channelling of more of his time and facilities to pressing research, as opposed to administrative duties. A type of orderly succession in office, favored in many TAPPI committees, was outlined.

Spurr moved and Mitchell seconded the institution of such an orderly succession in office hereafter in the TAPPI Forest Biology Committee, and the motion was *carried* unanimously.

Spurr moved and Ellis seconded the appointment of the present officers, Joranson, Zobel, and Wakeley, as a committee to nominate a slate of officers to be elected hereafter and to specify their terms of office and the filling of such vacancies as might occur. This motion was carried unanimously.

The meeting was adjourned at 11:45 a.m.

P. C. WAKELEY, *Secretary*

Report of Subcommittee Accomplishment for 1958

A short meeting of the newly created Subcommittee on Bibliography was held following the morning session of the full Forest Biology Committee on Feb. 18, 1958. At this meeting, tentative plans were made with respect to the subcommittee's scope and objective and the procedures to be followed in collecting and abstracting bibliographies references.

The results of this meeting were written up in the form of a progress report and submitted to the subcommittee members for suggestions and approval on March 25. The recommendations of the members were then incorporated in a final procedural outline issued June 25.

Progress was considerably delayed during the summer when three of the original six members requested that they be excused from their subcommittee assignments. In the meantime, four new members have been added to the subcommittee; two are participating members who will aid in compiling the bibliography and two will act in an advisory capacity.

A preliminary list of about 400 references has been circulated and at present about 300 of these have been selected by the members for abstracting. During the past winter, an additional list of 300 references has been compiled and several hundred more are anticipated as a result of cross-checking the literature.

As to plans for the coming year, we hope to have the majority of the references abstracted and perhaps we may have a preliminary draft of the final bibliography by the next meeting. This will be a sizable task since it will require each subcommittee member to abstract about 200 references. If permission can be obtained from the publishers of Forestry Abstracts to cite from their publication, considerable time can be saved, particularly with respect to the foreign and other difficult-to-obtain references.

Financially, the subcommittee has received $100 from the TAPPI executive committee for expenses. To date, we have spent $51.00 for Keysort cards, leaving a balance of $49.00.

Subcommittee on Tests and Quality Objectives

Chairman Jornason of the TAPPI Forest Biology Committee had hoped to have Malcolm May serve as chairman of what was originally called Subcommittee No. 2. Mr. May was obliged to refuse because of pressure of other work.

On April 23, 1958, Mr. Joranson appointed Peter T. Lannan, Jr., West Virginia Pulp and Paper Co., as chairman of Subcommittee No. 2.

On April 29, the chairman polled the subcommittee regarding a summer meeting, with encouraging response. On June 23, the subcommittee meeting was called for July 16, at TAPPI Headquarters in New York.

This first formal meeting of the subcommittee was held as scheduled July 16, 1958. The minutes were distributed to the members of the subcommittee, and were subsequently published in the October 1958 issue of *Tappi*.

Digest of Minutes, July 16, 1958, Meeting of Subcommittee No. 2

Meeting held at TAPPI Headquarters in New York.

Present: subcommittee members Echols, Lannan, Lyon, May, Mitchell, Pollock, and Yundt; others, Nethercut and Joranson. Special thanks are due to Joranson for serving as scribe.

"Subcommittee on Tests and Quality Objectives" was adopted as the name the subcommittee.

The two charges of the subcommittee were discussed and interpreted as follows:

First, "Delineation and relation of those fiber and wood characteristics of paramount importance to pulping and papermaking processes, and to sheet properties. The subcommittee adopts this charge, first, with the recommendation that information developed through its activities be addressed both to individual companies and to tree improvement personnel to aid in resolving decisions involving wood quality improvement. Second, the subcommittee wishes to underline the fact that today's decisions will affect wood quality in the future."

Second, "To study, recommend, and stimulate research on simple, economic, and meaningful small-scale tests of pulpwood quality, applicable to individual living trees. Tests must be nondestructive so as to permit the subsequent propagation and breeding of trees shown by the tests to be superior or unusual in regard to suitability for various classes of pulp and paper products."

These charges were adopted unanimously and were discussed at some length. Rather than attempt to specify wood qualities for each class of product, it was decided to work on areas of major interest common to many products. Two such areas are pulp yields and paper strength. It was also recognized that information is needed regarding the range of variations found in nature with respect to most of the factors affecting pulpwood quality.

Factors considered to influence *pulp yield* were discussed and listed as follows:

1. Wood specific gravity
2. Per cent holocellulose or alpha-cellulose (dissolving pulp)
3. Springwood-summerwood percentage
4. Extractives content
5. Knotwood and reaction wood content
6. Wood factors influencing ease of delignification

Factors influencing *paper strength* were also discussed and listed as follows:

1. Fiber strength, as influenced by
   a. Cell wall dimensions
   b. Degree of polymerization of cellulose and hemicellulose
   c. Degree of crystallinity
   d. Fibril angle
2. Bonding characteristics, as influenced by
   a. Hemicellulose content, type and distribution
   b. Fiber and cell wall dimensions
3. Fiber length

Mr. Yundt volunteered to prepare a writeup of a paragraph or two on each of the 13 wood and fiber characteristics listed—to be circulated among the Subcommittee with the expectation of final presentation to the Forest Biology Committee at the February, 1959, meeting. This was to be the goal for 1958. On Jan. 22, 1959, however, Mr. Yundt advised that he would be unable to complete the paper, as he was leaving the industry to start his own manufacturing.

Other members of the subcommittee were also busy.

Through Rick Salvesen, we received two reports on Micropulping for Cellulose Yield of Tree Increment Cores. One report dealt with Micropulping of Poplar, the other with Micropulping of Spruces, Soft Maple, and Poplar and Separated Growth Increments. These were reports from the Industrial Cellulose Research Limited, Hawkesbury, Ont., Canada. Vacations and sickness caused these reports to become buried. When they were resurrected, Mr. Joranson made an earnest effort to have the authors present a paper at the current annual meeting. Time was too short, so he is trying for 1960.

Dr. Robert M. Echols reported, in the January, 1959, issue of the *Journal of Forestry*, on the Ampliscope developed at the Southern Institute of Forest Genetics, U. S. Forest Service, at Gulfport. The Ampliscope is used to measure wood fibers from microscope slides.

Doubtless there are other developments that should be reported. Watch for them in the minutes of the second formal meeting of the Subcommittee on Tests and Quality Objectives.

There have been some changes in the membership of the subcommittee, which today stands as follows:

T. W. Earle, General Manager, Woodland Department, Continental Can Co., Inc., P. O. Box 607, Savannah, Ga.
Robert M. Echols, Southern Institute of Forest Genetics, U. S. Department of Agriculture, Forest Service, 3505 25th Ave., Gulfport, Miss.
Peter T. Lannan, Jr., *Chairman*, Research Administration, Woodlands Division, West Virginia Pulp and Paper Co., Box 587, Georgetown, S. C.
Malcolm G. Lyon, Manager of Pulp Research and Development, The Champion Paper and Fibre Co., Hamilton, Ohio
Donald J. MacLaurin, Chief, Pulping and Papermaking Section, The Institute of Paper Chemistry, Box 498. Appleton, Wis.
Malcolm N. May, Technical Director, Gulf States Paper Corp., Tuscaloosa, Ala.
Harold L. Mitchell, Forest Products Laboratory, U. S. Department of Agriculture, Forest Service, Madison 5, Wis.
Thomas O. Perry, Division of Biology, Ehrhardt Laboratory, California Institute of Technology, Pasadena, Calif.
F. E. Pollock, Associate Director, Technical Division, The Buckeye Cellulose Corp., Memphis 8, Tenn., (Mr. Louis A. Hiett, serving as alternate at February, 1959, meeting)
J. R. Salvesen, Director of Research, Marathon Corp., Rotschild, Wis.
Robert J. Seidl Director, Central Research, Simpson Timber Co., Seattle, Wash.

It has been an experience to serve as chairman of this subcommittee. We do not have a lot to show for our efforts, but we have made a start. I sincerely appreciate the cooperation I have received from the subcommittee members. To them and to you, Thank you. P. T. Lannan, Jr., *Chairman*

Semichemical Pulping Committee

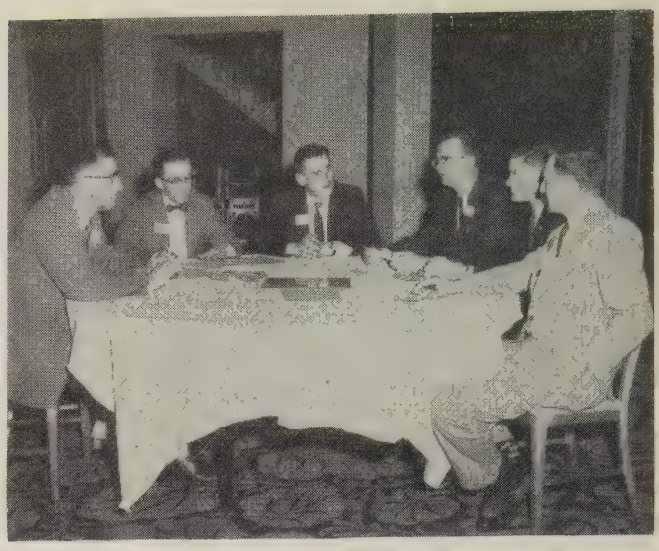
A meeting of the Semichemical Pulping Committee was held at the Hotel Commodore, New York, on Monday, Feb. 23, 1959. Those present were:

P. E. Trout, Waldorf Paper Products Co., St. Paul, Minn.
D. Adams, West Virginia Pulp & Paper Co., Covington, Va.
R. E. Collins, The Crossett Co., Crossett, Ark.
G. Kimble, Union Bag-Camp Paper Corp., Savannah, Ga.
C. Christiansen, Diamond Alkali Co., Painesville, Ohio
M. J. Troster, Union Bag-Camp Paper Corp., Savannah, Ga.
G. H. Chidester, Forest Products, Madison, Wis.
G. E. Soyka, John W. Bolton & Sons, Inc. Co., Lawrence, Mass.
S. R. Parsons, Consolidated Water Power & Paper Co., Wis. Rapids, Wis.

The following officers were nominated to serve for the coming year:

P. E. Trout, *Chairman*
R. E. Collins, *Vice-Chairman*
S. R. Parsons, *Secretary*

The motion was made and passed that the chairman should write a letter to an executive in all companies manufacturing semichemical pulp soliciting active membership in the committee. It was suggested that the secretary should write to each committee member well in advance of each meeting to help encourage attendance at the committee meetings.



Semichemical Pulping Committee

Mr. Collins will remain the program chairman through the Nov. 4–6, 1959, meeting. He stated that five papers had been promised for this meeting. Mr. Adams stated that the Alkaline Pulping Committee had allotted a half day only for the semichemical session and a longer program could not be accommodated at this meeting. Mr. Collins asked to be relieved of the responsibility of program chairman of meetings beyond the November, 1959, meeting.

It appeared evident that sufficient papers could be obtained to justify a semichemical session at the national meeting in February, 1960. It was moved and passed that the chairman and vice-chairman decide on the program for this meeting.

Committee projects were discussed. The reasons were given for the rejection of the request funds for the proposed study on stock preparation. It was voted not to renew the request for funds for this study and also not to initiate any new projects until the committee is enlarged and becomes more active.

S. R. Parsons, *Secretary*

Routine Control Methods Committee

A meeting of the Routine Control Methods Committee was held at the Hotel Commodore, New York, N. Y., Feb. 24, 1959. The meeting was called to order at 9:00 a.m. in Room E by Chairman J. R. Gunning. The following members and visitors were present:

J. R. Gunning, Abitibi-Provincial Paper Co.
Edwin H. Benz, Scott Testers
John Willy, Norton Specialties Co.
C. L. Stumpp, West Virginia Pulp & Paper Co.
C. L. Hess, Minnesota & Ontario Paper Co.
L. J. Slentz, Solvay Process, Div. Allied Chemical
R. S. Hunter, Hunter Associates Lab.
B. Q. Haynes, B. F. Perkins & Son, Inc.
F. O. Sundstrom, American Cyanamid
P. S. Cade, Harding-Jones
D. Noel Obenshain, West Virginia Pulp & Paper Co.
R. D. Faunce, Reynolds Metals Co.
L. M. Tyler, Howard Paper Mills, Inc.
A. J. Winchester, TAPPI
M. P. Boland, Columbia—Southern Chem. Corp.
L. C. Aldrich, West Virginia Pulp & Paper Co.
C. E. Brandon, Miami University

The minutes of the September meeting in Savannah were read by Secretary Haynes. C. L. Hess moved that the min-

Routine Control Methods Committee

utes be accepted as read. E. H. Benz seconded and the members passed the motion.

Chairman Gunning then read a letter from Jack Winchester, dated Jan. 16, 1959, in reference to the adopted method of the committee in processing R. C. Methods. Mr. Winchester proposed, in his letter, that the committee consider omitting steps three and four in the interest of expediting publication of the methods. In the discussion that followed the proposal, it was pointed out by various members of the committee that steps three and four, in their opinion, served a very useful purpose of screening the contents of the proposed methods prior to publication in *Tappi*. It was felt that certain time limits could be placed on the editorial process to speed up processing.

Several proposals were made in this connection. L. J. Slentz proposed the following revisions:

1. Add under Step 1
   "(c) A proposed R. C. Method received at TAPPI Headquarters."
2. Under Step 2
   Substitute the word "recipient" for the word "committeeman."
3. Under Step 4
   Substitute the words "within ten (10) days" in place of "in a reasonable time."

R. S. Hunter and P. S. Cade moved and seconded a motion that these revisions be adopted and the revised processing procedure be published in *Tappi*. It was so voted by the committee.

The revised procedure for processing a proposed R. C. Method is as follows:

1. (a) The author of a proposed R. C. Method submits his method to a member of the R. C. Methods Committee.
   (b) A proposed R. C. Method is uncovered by a member of the group.
   (c) A proposed R. C. Method received at TAPPI headquarters.
2. The recipient immediately sends one copy of the proposed R. C. Method to the editorial chairman.
3. The editorial chairman follows up with the committeeman and the author, until in his opinion, it can be sent to A. J. Winchester, TAPPI Headquarters, 155 East 44th St., New York 17, N. Y. At headquarters, copies will be made after editing and sent to the following:
   (a) Editorial chairman.
   (b) Chairman of R. C. Methods Committee.
   (c) Secretary of R. C. Methods Committee.
   (d) Committeeman who was responsible for securing the method.
   (e) Author.
   (f) Any TAPPI member that headquarters feels could contribute.
4. All Members receiving the above copies will be asked to return them within ten (10) days with comments, to Headquarters, attention A. J. Winchester.
5. The method will be published in the *Tappi* magazine under the heading,
   "Routine Control Method
   This is NOT a TAPPI Standard

The author of the following method has found it useful in control. It is issued only to assist in control and comments, are invited and should be addressed to A. J. Winchester—TAPPI."

6. The editorial chairman will review all methods published in the *Tappi* magazine, with the comments received and prepare for annual publication in loose leaf form.

Jack Winchester reported that R. C. Methods publication would be started in the February issue of *Tappi*. The methods to be published will be:

Density or Volume of Small Specimen (hq. Pycnometer)
Block-Tensile Test of Bonding Quality
Pin Test of Bond Quality in Corrugated Board
Speed of Grab Adhesion Test

Chairman Gunning stated that he had approximately 25 proposed methods for review and revision. C. L. Stumpp accepted the assignment, in behalf of his subcommittee, of reviewing them in preparation for publication in *Tappi*. The methods now under review by this subcommittee are as follows:

Sodium in Kraft Lime Sludge (Flame Photometer Method)
Analysis of Salt Cake (Colorimetric Determination of Magnesium)
Analysis of Weak Black Liquor for Active Alkali
Sodium Salt Content of Kraft Pulp (Flame Photometer method)
Efficiency Test for DC Antifoams
Determination of Per Cent Elongation of Creped Paper
Internal Bond Test (Scott Bond Tester)
Determination of pH in Paper (Brom Cresol Indicator Solutions)
Mullen Burst Test and Hardness Index of Pulp
Stiffness in Paper and Board (Gurley)
Analysis of Neutral Sulphite Semichemical Liquors
Porosity—Smoothness—Softness of Paper (Gurley)
Porosity of Paper (Sheffield)
Tensile Strength of Paper (Electro-Hydraulic Tester)
Degree of Sizing in Paper (Currier)
Relative Humidity (Bendix Pyschron)
Smoothness of Paper (Sheffield)
Formation in Paper (Thwing-Albert)
Softness-Stiffness in Paper (Clark)
Pin Adhesion Strength of Corrugated Board
Porosity, Air Permeability of Air Resistance of Paper (Gurley)
Torsion Tearing Strength of Paper (IPC Torsion Tear Tester)

Chairman Gunning then announced the resignation of P. S. Cade as chairman of the Supplier Liaison subcommittee. Action on Mr. Cade's resignation had been deferred from the September meeting to allow time to appoint a successor. Mr. Gunning commended Mr. Cade on his willingness to carry on to the February meeting and thanked him for the fine work he had done for the committee. Mr. Gunning then announced that Lyman Aldrich had agreed to serve as Mr. Cade's successor and was thereby appointed chairman of the Liaison subcommittee.

A discussion then followed in regard to editorial policy in connection with R. C. Methods which included operating instructions for the equipment involved. It was voted to adopt the following policy:

1. Methods involving accepted standard equipment.
   The method should refer the reader to the manufacturers of the equipment for instructions for operation, standardization, etc.
2. Methods involving new equipment or a new concept.

The method should contain brief but complete instructions for operation and standardization.

3. Methods submitted involving competitive equipment in an already existing R. C. Method.
   The Review and Revision Subcommittee will edit and publish it as an amendment to the original R. C. Method.
4. In general, R.C. Methods should be as concise as possible using references, whenever possible, to existing easily available material. Elaborations, if proved necessary, could be added later as amendments.

C. E. Brandon was then called upon for comments. He stated his gratification in the progress made by the R. C. Methods Committee and stated that he was particularly impressed by the interest shown by other TAPPI committees by preparing and submitting R. C. Methods for publication.

The meeting was adjourned at 11:20 a.m.

The second session of the R. C. Methods Committee was opened at 3:45 p.m. in Room E by Chairman Gunning. The following members were present:

Clyde Eckhart, Ohio Boxboard Co.
Cecil L. Hess, Minnesota & Ontario Paper Co.
M. P. Boland, Columbia-Southern
P. S. Cade, Harding-Jones Paper Co.
B. Q. Haynes, B. F. Perkins & Son. Inc.
F. A. Delforge, Continental Can Co., Gair Div.
J. R. Gunning. Abitibi-Provincial Paper Co.
C. L. Stumpp, West Virginia Pulp & Paper Co.
L. J. Slentz, Solvay Process Div.
F. C. Schmutz, New Jersey Zinc Co.
L. C. Aldrich, West Virginia Pulp & Paper Co.
F. O. Sundstrom, American Cyanamid Co.

The first 45 minutes were spent in organizing the Supplier Liaison Subcommittee. The following new members were added to this group:

Jack Storin, Hercules Powder Co.
F. O. Sundstrom, American Cyanamid Co.

Chairman Gunning stated that he had already reviewed and was submitting the following methods for publication in *Tappi:*

Plybond Test of Paperboard (Involving the Jumbo Mullen Tester)
Film Identity Test

The meeting was adjourned at 5:00 p.m.

B. I. Haynes, *secretary*

Adhesives Testing Committee

The seventh meeting of the Testing of Adhesives Committee was held in New York, 24, 1959.

Morning Session

The morning Adhesive Testing Session, open to all attending the Annual TAPPI Meeting, drew a full house of over 200. Papers presented were:

"Predicting the Glueability of Milk Carton Stock," by H. J. Ladue of Pure-Pak Laboratories.
"Evaluating Industrial Adhesives," by H. G. Meeder of Dixie Cup.
"Fundamentals of Adhesion," by H. F. Mark of Polytechnic Institute of Brooklyn.

The three papers were enthusiastically received as indicated by the applause and by the questions each evoked. Some or all of the papers will be published in forthcoming issues of *Tappi.*

Afternoon Session

Members Present: Neuss, Sederlund, Carey, Bearman, Breslouf, Brown, Crowell, Erickson, Faunce, Fox, Godshalk, Heise, Herman, Minelli, Nichol, Riggs, Sams, Schmid, Weizenhoffer, Wilkins, Yang.

Guests: George Adams, Metropolitan Life; J. J. Bikerman, M.I.T.; L. R. Brantley, Occidental College; L. D. Brugh, West Virginia Pulp & Paper; Roy Charron, U. S. Envelope; H. S. Eldridge, United Paste and Glue; P. Goldberger, Stein Hall; Ralph Green, Thwing-Albert; Arthur Hirsch, General Gummed Products; A. Plummer, Stein Hall; T. Porowski, Velsicol Chemical Corp.; H. Ritterspoon, Stein Hall; P. J. Shirley, Penick & Ford; M. E. Stern, Morningstar-Paisley; E. E. Werle, Darling & Co.

Adhesives Testing Committee

The meeting opened at 2:30 p.m.

The minutes of the Dec. 10, 1958, meeting, as published by the secretary, were accepted.

New members present, Leslie C. Riggs of Armour & Co. and George G. Schmid of Riegel Paper, were duly welcomed by the chairman.

Mr. Heise spoke on the general progress in the Technical Section of the Gummed Industries Association. On an initial canvass of G. I. A. members, five test methods had been received, rewritten in approved format, and would be offered to G. I. A. membership for adoption. A modified McLaurin test in which the delay time between application of tape and the start of separation will be controlled, is being studied. Photos of the Herrlinger Gummed Tape Adhesion Tester were circulated. This instrument was designed by P. W. Herrlinger of Gummed Products (U. S. pat. 2,604,783, July 29, 1952) and a license arrangement is available.

L. R. Brantley of Occidental College, currently at the Department of Chemistry, Lehigh University was introduced. He offered to answer questions on theoretical aspects of adhesion and adhesives. The chairman also introduced J. J. Bikerman of M.I.T., who has written extensively on adhesion theory. It was announced that Mr. Bikerman will conduct an intensive course—30 hours—June 29 to July 3 at M.I.T. Details may be obtained from Director of the Summer Session, Massachusetts Institute of Technology, Cambridge 39, Mass

Mr. Neuss discussed the summary report on the cooperative testing on the Bashore T-A-C Tester as modified by Thwing-Albert. It was the sense of the committee that the report should be adopted after deleting the theoretical discussion at the end. Mr. Green of Thwing-Albert had no objection to the report, which was critical of the manual device for bond rupture. The feature in question has been replaced by a dead weight which eliminates a source of variation. The chairman will discuss with Jack Winchester of TAPPI what action will be taken to publish the report.

In a general discussion on tack or tackiness, the chairman called attention to the following literature references which he felt were worth each member's reviewing.

1. J. J Bikerman, Dept. of Civil & Sanitary Engineering, M.I.T.
   a. Fundamentals of Tackiness and Adhesion, *J. Colloid Sci.* 2: 163–75, *Chem. Abstr.* 41: 2959f.
   b. The Tackiness of Liquid Adhesives, *Trans. of the Soc. of Rheology* Vol. 1, 1957, p. 3–14.

c. The Rheology of Adhesives, a chapter in Eirich's Rheology, Vol. 3, due for publication Aug. 1959, by Academic Press.

2. L. Reed Brantley, Dept. of Chem. Lehigh Univ. Bethlehem, Pa.

a. Final Report on Adhesion for Office of Naval Research.

Monograph assignments were reviewed. The foil laminating group was augmented by Mr. Schmid of Riegel. Mr. Sams reported that he is half way through the first draft of his chapter. Other groups reported varying degrees of progress.

The next meeting will be held at 9:30 a.m. on May 13 at TAPPI Headquarters.

The meeting was adjourned at 4:30 p.m.

J. P. Carey, Jr., *Secretary*

Pulp Testing Committee

A meeting of the Pulp Testing Committee was held at the Commodore Hotel, New York, N. Y., Feb. 23, 1959, with the following attendence: Frank Caskey, John C. Cousins, Gordon Rabeler, J. R. Arthur, Harold T. Randles, R. R. Chase, C. S. Walseth, E. Christoferson, Paul Boronow, H. A. Smith, E. L. Rastatter, and R. E. Green.

The meeting was called to order at 2:00 p.m. by H. A. Smith, chairman.

The minutes of the previous meeting in Savannah were read and approved.

The summer meeting in Portland, Ore., was discussed. The theme of this meeting is to be Pulp Testing. Four papers are now available, and several others would be welcome. Frank Caskey, a real Oregon booster, promises a pleasant and worth-while visit to his area. Side trips of great interest are being planned. This visit can tie in with the Oregon Centennial Year celebration. Let's all make an effort to get there.

Paul Boronow of Valley Iron Works reported on the situation that led to their decision to change the hardness of the tackle bars in the $1^1/_2$ lb. Valley beater. A sudden rash of complaints about instability and variation of results from mechanically perfect beaters caused the sudden decision to increase the hardness of both the fly bars and bed knife bars. After grinding in, results are the same as with the old tackle. New bed knife bars can be used with old fly bars. Any bars shipped after May 15, 1958, would be of the new hardness specification. From the invoice date, Valley Iron Works can identify the steel in any bars a customer may have.

New fly bars 350 to 400 Brinell.

New bed knife bars 325 to 375 Brinell.

Mr. Boronow apologized for making the change without notification of the proper authorities and promised to keep the committee fully informed if any future changes are under consideration.

Mr. Caskey proposed, seconded by Mr. Cousins, that the new knife hardness specifications be accepted. The motion was unanimously passed.

Report on Active Projects

No. 132, Revision of T 200 m-45—Laboratory Beater. Frank Dinger's method ("80-grit-tough-up" method for maintaining calibration of the Valley laboratory beater) seems most acceptable, being fast, easy, and reproducible. Messrs. Rabeler and Chase are well satisfied with it.

No. 448, Revision of T 213 m-43—Dirt in Pulp. The present method is not precise enough to be used as a referee method. The customer is always right. The only hope seems to be some type of mechanical counting method to eliminate human errors and differences, said Mr. Christoferson.

No. 470, Pulp Consistency. Cousins was not ready to report at this time but will have something for the August meeting.

Pulp Testing Committee

No. 611, Forming Handsheets for Physical Testing of Pulp for Corrugating Medium. This is complete and was given to Mr. Delforge at the Savannah meeting. This is now in the hands of Routine Control.

No. 636, Testing High Freeness Pulp. Mr. Chase said that The Institute of Paper Chemistry is working on this as a project. Their results should be considered.

No. 751 Second Round-Robin Testing of Reference Pulp. It was voted at Savannah to secure a second test on this pulp if possible. Of 10 mill laboratories approached, of agreed to conduct the tests. Three institutional laboratories begged off, as they had no money to run these tests. The testing will be done, and the results of 22 beater tests in 11 different beaters will be available. Testing of opacity, density, and single sheet caliper is being eliminated. The results of these new tests should be available at the August meeting.

The meeting adjourned at 4:30 p.m.

E. L. Rastatter, *Secretary*

Tenth

Testing Conference

of the

Technical Association

of the

Pulp and Paper Industry

Multnomah Hotel

Portland, Ore.

Aug. 17–21, 1959

ENGINEERING DIVISION

Committee Contributions

Questions and Answers

(*4*) *Question:* What is the basic consideration used in choosing a synchronous motor for a particular drive in preference to an induction motor?

(*4.2*) *Answer:* Fundamentally, any piece of equipment can be driven by a NEMA design, B squirrel cage motor can likewise be driven by a synchronous motor.

A general rule of thumb is that the following motors be synchronous:

(a) Motors below 500 r.p.m. and above 200 hp.
(b) Motors 500 to 1200 r.p.m. if more than 1 hp. per r.p.m.
(c) 1800 r.p.m. motors, 200 to 1000 hp., if power factor improvement is important.
(d) 3600 r.p.m. motors above 5000 hp.

Synchronous motors have better power factor characteristics and, usually, better efficiency so final choice must be considered: hours of operation per year, load factor, incremental cost of power per kwh; evaluation of power factor improvement versus difference in first cost, and slightly higher maintenance cost of synchronous motors. Both types are considered of adequate reliability for usual industrial applications. In some cases short time current rating and interrupting capacity of breakers may be adversely affected by the presence of synchronous motors. This matter should also be checked.

The above is necessarily an oversimplified approach to the matter of selection of synchronous versus induction motors. I believe it is fairly representative as far as it goes. A volume could be written on this subject, but I hope the above will suffice.

(*6*) *Question:* A recently installed gear unit is showing pitting on the gear teeth at or near the pitch line. What is the cause and cure for this condition?

(*6.1*) *Answer:* Pitting of gear teeth is the result of subjecting the surface of the metal to loads that create shearing stresses in excess of the fatigue limits of the material and when the surface fails in fatigue, metal particles drop out.

In new gears there may be high spots on the surface of the teeth that will take most of the load. These high spots will fail and the load will be redistributed to other areas. If these redistributed loads do not create shearing stresses in excess of the fatigue limit of the material, the gears will probably continue to perform in a satisfactory manner, and as they wear the pits may disappear and the tooth become smooth and glossy.

If there are no high spots on the tooth and the load is distributed across the full face and pitting occurs, the problem is one of overload on the gearing. The only solution to this problem is to reduce the load or increase the size of the gear, or use a gear of harder material. For a complete treatise on this problem, refer to American Gear Manufacturers Association standard entitled "Surface Durability of Spur Gears"—reference no. 210.01 or "Surface Durability of Helical and Herringbone Gears"—AGMA standard no. 219.05 and "Gear Tooth Wear Failure"—AGMA standard 110.02.

(*7*) *Question:* In the designing of the breast, table, and wire rolls for a fourdrinier, what criteria are used to determine the allowable deflection when the rolls are to be operated at speeds which do not involve consideration of critical values?

(*8*) *Question:* What are the causes of premature replacements of roller bearings on paper machinery?

(*8.1*) *Answer:* It is an established fact that bearing size selections for paper machines is based on a B-10 life of 100,000 hr. of operation. With a maximum working year of 8210 hr. (full year minus 550 hr. for repairs, felt and wire changes, etc.) the B-10 life would be approximately 12 yr., but many mills have had the experience of bearing replacements within this predicted time interval.

B-10 life is an arbitrary definition designating the minimum number of hours of life expectancy for 90% of any group of bearings before there appears any evidence of metal fatigue.

From repeated tests over the years by bearing manufacturers, life dispersion curves of any group of antifriction bearings under identical loads, speed, and all other conditions shows the life expectancy of 10% of the group is not predictable.

Over the years, there have been several informative pieces of literature written which explain in detail, with microphotographs, the reasons for premature replacements of roller bearings. This literature is as follows:

1. "Inspection Procedures For Anti-friction Bearings" published by the Army Air Force as of April 1, 1945. Their publication T. O. No. 04-20-2.
2. "Interpreting Service Damage in Roller Type Bearings" as sponsored by the technical committee on bearings and bearing lubrication of the American Society of Lubrication Engineers, 84 East Randolph Street, Chicago 1, Ill. This pamphlet can be secured for $1.00 per copy.
3. An article appearing in the October, 1956, issue of *Product Engineering* entitled "Why Bearings Fail," by D. F. Wilcock and E. S. Booser of General Electric Co., Schenectady, N. Y.

The major terms used to describe the appearance of roller bearings requiring replacement are:

1. Flaking—the removal of material from a surface in the form of flakes or scalelike particles.
2. Electric pitting—a form of pitting produced by the passage of electric current across two surfaces.
3. Fluting—a form of pitting in which the pits occur in a regular pattern so as to form grooves or flutes.
4. Corrosion—the wearing away of substance by chemical action.
5. Cracks—narrow openings made by parting of any substance, usually without removal of material.
6. Smearing—the removal of material from one point on either of the surfaces of two bodies in sliding contact.
7. Indentation—surface depressions formed by deformation without removal of material.
8. Wear—the rubbing away of a surface by mechanical action.

Perhaps one of the least understood terms in the study of causes of damage to roller bearings is the term fatigue which appears in its last stages of bearing failures as "flaking."

Fatigue is caused by alternating stresses which result in the eventual formation of fatigue cracks, usually starting at the point of maximum shear stress just below the surface of the bearing metal. As an individual roller moves over the maximum load zone point, the outer race of a bearing is subject to a maximum stress, which is immediately relieved until the next roller moves into position—thus, the outer race throughout its life is subject to alternating or reversal stresses.

The proper selection of bearing sizes for all given applications should be made to provide for sufficient alternating and reversal stresses to give a B-10 life expectancy of 100,000 hr., before metal fatigue from these alternating or reversal stresses requires premature replacements of the bearings.

Aside from actual bearing defects which actually account for a relatively small percentage of bearing replacements, the major causes of replacements are due to:

Corrosion—Due to (a) moisture or acid attack while the bearing is stationary for long periods. Due to (b) corrosion lubricant or free water in the lubricant. Due to (c) corrosion atmosphere and condensation within a bearing enclosure.

Smearing—Due to (a) inefficient lubrication—this occurring more readily under conditions of higher steam temperatures, for example, in paper driers, than at lower steam temperatures.

Cracks—Due to (a) too tight a fit of inner races on journals. Due to (b) nonuniform seating surface between bores of inner races and journals. Due to (c) deformation of housing bores, causing circumferential cracks in races.

Indentations—By blows in mounting or improper mounting procedure and/or presence of dirt.

Wear—Caused by abrasive matter or a gummed lubricant.

In conclusion and for a most complete understanding as to the causes of premature replacements of roller bearings, it is fully recommended that a study and perusal be made of the above-listed three treaties on the subject, from which some of the above answer has been taken.

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel, and Events

Chicago

The April meeting of the Chicago Section of TAPPI was held on Tuesday evening, April 7, at its usual meeting place, Chicago Bar Association quarters.

A fairly good attendance of members and guests heard a very interesting presentation on "Design and Research in Packaging" given by Ray Howard. Mr. Howard is assistant research manager, Container Corp. of America, Design Laboratory. Mr. Howard supplemented his talk with colored slides to emphasize certain aspects and to present vivid pictorial examples of some of the problems encountered in his work. The main theme of his discourse concerned the importance of good design, format, or motif, and color selection and how these characteristics influence consumer psychology and acceptance or rejection. Audience interest was continuously stimulated by appropriate examples to describe situations of Mr. Howard's lively discourse. A brisk responsive question-and-answer period followed the presentation.

Other business of the evening concerned the announcement of proposals to amend the constitution of National TAPPI and how this would affect the voting rights of members. Announcement was also made by the nominating committee of candidates selected for office for the next season.

CARL M. HELM

Design and Research in Packaging

Raymond C. Howard

THE demands of contemporary business have forged two relatively new weapons in the arsenal of marketing or product merchandising: design and research. Commercial design and business research practices are being implemented more frequently as weapons developed to give their users a sales advantage on a highly competitive retail battleground. Commercial research and design have grown with an expanding management need—to reach the consumer more quickly, more efficiently, and with greater impact. Before we discuss current research and design practices, however, let us stop a moment to examine the history of the *need* for these functions. In short, to fully understand why research and design have become important to contemporary business management.

Nineteenth century business employed neither designer nor researcher. Contemporary business demands the services of both. At first glance, we would assume that basic business requirements have changed thus necessitating the growth of highly specialized advisory services. The simple business establishment of yesterday breathed in a less complex environment according to some experts. But is this really true? Have business objectives and requirements basically changed during the last 70 years? The essential components of nineteenth century business, sales, production, and cost control are still the main ingredients in contemporary business. Sales requirements are still identical if we look at selling as the ability to meet customer needs quickly, efficiently, and pleasantly. And the final objective of business management—to win the highest possible returns on invested capital—has not changed at all. So vicissitudes in business objectives and requirements cannot be listed as reasons underlying the growth of research and design in contemporary marketing management.

Well, then, why do we have the researcher and designer with us today? To provide an answer, let us look again at the nineteenth century businessman. But to simplify our discussion, let us put aside for the moment the roles of production and cost control so that we may concentrate more accurately on sales problems.

The businessman of yesterday *knew* his customers. He understood their needs—both tangible and abstract—and as a result was able to tailor his sales approach and products to fill existing customer needs. Research, design, and other communication services were unwanted and un-needed.

But as business grew, people began to grow between the businessman and his customer. There were salesmen and brokers. Then came the retail store. As concentration increased, the wholesaler stepped between the retailer and the businessman's sales force. With growth came consolidation, and with consolidation came concentration. The process was repeated continually. The result: the businessman no longer really knew his own sales force and he was completely and hopelessly divorced from his ultimate customer—the consumer. No longer could he, or his sales force meet the ultimate customer—Mrs. Consumer. The divorce would not have had such serious consequences however if certain phenomena had not developed.

1. Despite the growth of big business and corporate concentration, business became increasingly competitive.
2. Communications improved, allowing business to compete with ideas as well as products.
3. Big business and national markets meant that selling costs—especially new business expenses—grew spectacularly.

RAY HOWARD, Assistant Research Manager, Design Laboratory, Container Corp. of America, Chicago, Ill.

Speakers table at the Chicago Section meeting: C. M. Helm, American Cyanamid Co.; H. J. Klauke, Container Corp. of America; R. C. Howard, Speaker; M. W. Snover, Hollingsworth & Vose Co.; M. H. Meyer, Container Corp. of America; and W. D. Kenney, Ace Carton Corp.

R. C. Howard, Container Corp. of America, speaker at the April meeting of the Chicago Section

The reward potential for success was great but the penalty for failure became staggering.

4. The ultimate customer or consumer became a moving target in the twentieth century. Unlike her nineteenth century sister, the modern consumer was easily dissatisfied with the status quo and demanded products conducive to improved living standards. This creates a dynamic market where the key words were "new," "better," and "easier."

These factors, increased product competition, idea competition, rise of selling costs, and changing consumer tastes, placed the out-of-touch businessman in jeopardy. The need became clear—to make the businessman and his customer one once more. A remarriage was necessary. The remarriage has taken the form of advisory services. Advertising, public relations, product styling, package design, and marketing research. These functions grew as specialized services designed to bridge the separation between consumer and manufacturer.

Research would provide sales and production with information concerning consumer needs and attitudes.

Design would style products and packages to mesh psychologically and physically with the consumer's attitude patterns.

Advertising would tailor sales messages so as to stimulate a favorable response action at the consumer level.

Rather than discuss marketing and market planning, however, let us examine the place of design and research in packaging efforts. And let us examine packaging in its role of manufacturer's representative or front line salesman.

When the manufacturer was in the middle stages of his divorce trend, he could often—through effective trade relations practices—depend on the retailer to act as his front line salesman or good will spokesman. But as the divorce became complete, the retailer stepped out of this sales role and shifted the burden of selling to the manufacturer's package. The retailer no longer cared which brands or products were in his store. Instead he shelved those items which supplied the most favorable volume-profit returns. This shift of responsibilities meant that the manufacturer's total corporate efforts were funneled to the consumer through package design. (The importance of advertising is obvious, but this function falls outside the scope of this paper.) The problem became one of developing package designs with optimum sales power. This demand led to the growth of design as a corollary or sometimes integral part of corporate marketing programs. The designer, however, was not able to provide consistently an accurate answer to sales or marketing problems. Much of the designer's difficulty rested in the nature of his product. Design—or any graphic approach—is controversial. Nonexperts consider themselves experts and the personal inclinations of management all too often failed to impress the consumer.

A vice-president of a soap manufacturing firm was once confronted with five proposed designs for a new bar soap product. He favored one approach quite strongly. He fetl that "if it looks good to me it ought to look good in the store." He allowed the designs to be researched, however, and found that his favorite would be least effective in presenting desired feminine appeals. The reason—his favorite was judged by the consumer to be representative of a male or masculine specialty soap. It is small wonder that the "masculine design" would win his favor initially.

Because the designer's product was not easily judged by management, the need for more scientific evaluation grew. To fill this need, the market researcher entered the business scene. He brought techniques and practices developed at universities to cast some light on design evaluation. His techniques and approaches included statistical sampling, psychological interviewing, and perceptual testing—each a subject unto itself. In time, however, the researcher acquired business experience and began to adapt rigid techniques to the solution of business problems. Thus, although we will discuss some research approaches or categories, it is important to emphasize that each business problem is unique or individual, demanding tailored—not rigid—technique application.

Package evaluation, often falls into two broad categories: perceptual research and attitude or image evaluation. Perceptual research is concerned with how well a package can be seen in a competitive environment. Attitude research, on the other hand, deals with the impressions created by design once the package is seen. In order to evaluate the perceptual characteristics of design, the Design Laboratory of Container Corp. has adapted and developed a group of instruments designed to measure factors determining visual effectiveness.

The relative visibility meter measures how effectively a design communicates copy messages and symbols under varying lighting conditions. Superior mechanical visibility provides a package with a definite visual advantage in the market place.

A device has been developed to evaluate design recognition when the package is viewed at various angles. This measurement simulates the market place where consumers approach packages from aisles. A design that conveys its messages across a wide angular range is one which offers greater opportunity of attracting initial attention.

The ocular camera is an ingenious device which records eye dwell patterns of consumers viewing competitive designs. When the eye patterns are charted for study, three indications of design effectiveness are obtained: initial visual impact, sustained attention, and layout effectiveness.

Tachistoscopic tests are employed to measure the effectiveness of designs in conveying brand, product, and sales messages during limited viewing periods. These tests determine the accuracy of design efforts in projecting and establishing key messages or impressions.

Once a design has satisfied perceptual requirements, it would be subjected to consumer evaluation, or, in some instances, to dealer evaluation depending on the manufacturer's distribution practices.

Psychological techniques may be employed to uncover and evaluate more-than-conscious or emotional responses. There are many instances where emotional involvement prevents a consumer from providing an accurate answer to a direct question. Products are often sold and promoted with emotional overtones. To measure the effectiveness of these approaches, depth or psychological interviewing is often required. Specialty foods, ice cream, patent medicines, and toiletries would be examples of products where psychological package research would be important.

Psychological research may be supported with projective or

attitude surveys which employ structured questionnaires and large samples to validate or discard hypothesis uncovered in depth interviewing. The consumer is exposed to indirect questions formulated in focus specific answers on design requirements. For example, does a proposed milk carton design provide impressions of purity, nutrition, sweetness, coolness, and refreshment? A successful design must satisfy these essential consumer expectations for milk. On the other hand, an expensive appliance must convey an image of quality, confidence, prestige, and durability. These qualities are inherent in effective design for expensive mechanical products.

Statistical research practices may be instituted to assess market behavior. In this procedure, relatively simple questionnaires employing direct questions would be administered to broad samples. Surveys would be designed to study certain living or behavior habits easily discovered through direct questioning or observation. For example, this type of research would be used to study the compatibility of cereal box sizes to shelf or pantry conditions.

Problems occurring at intermediate distribution levels would necessitate dealer or distributor interviews. A large national textile market may be surveyed relatively inexpensively by interviewing textile buyers of key department stores and soft-goods houses. Often the buyer's response is a condensation of consumer opinion in his area. Distributors and dealers in the hard goods industries may be interviewed to determine the communications effectiveness of packaging in warehouse conditions. Photographic surveys may be utilized to record visually retail or wholesale display conditions. Through this type of study, it is possible to accurately assess a design's competitive environment and its mass display performance.

Advertising utilized by an industry may be studied to determine the consumer appeals used by advertisers in product promotion. The appeals or expectations exploited in advertising communication should be reflected in packaging. Where a conflict appears, a salient sales effort will be diluted.

Information obtained in research is utilized by the designer to expand his knowledge of the packaging problem. He will apply his creative resources to develop a visual solution compatible with competitive product requirements.

Research may follow the development of designs and act as an arbiter to guide management in decision making. It is important to remember, however, that design and research function cooperatively in helping the contemporary business manager to reach his consumer more effectively. It is the role of both design and research to develop packages which are perceptually and psychologically outstanding while keying design to an effective marketing philosophy.

Presented at the meeting of the Chicago Section of TAPPI held in Chicago Ill., April 7, 1959.

Indiana District

This meeting of the Indiana District of the Ohio Section was held April 21, 1959, in Greencastle, Ind. It included a tour of the International Business Machine plant in Greencastle, Ind. This is IBM's principal punch card printing operation and has a capacity of 80 million cards daily. Richard V. Flynn officiated for IBM and before taking the plant tour, the group heard a short discussion of the operation and saw the IBM film "The Cards that Count."

The business meeting was held at the Elk's Club in Greencastle and 39 members and guests were present.

In the absence of our program chairman, Chas. E. Eberly, Harris O. Ware conducted the meeting which consisted principally of the nominating committee's report made by Edward Piatt of Inland Container Corp.

The following nominations were made for officers and the executive committee for the 1959–60 season:

Officers

Chairman— Charles E. Eberly
Vice-Chairman—Programming— W. D. Boggess
Vice-Chairman—Membership— John S. Sullivan
Secretary— Cushing Roth
Treasurer— Thomas F. Sullivan

Executive Committee

S. R. Sutphin, W. B. Lincoln, Jr., Melvin L. Johnson and Harris O. Ware

The chairman called for nominations from the floor and none were forthcoming. Neil Balfour made the motion that nominations be closed and this move was seconded by Larden Hoffman.

The minutes of the March 17th meeting were read and approved and the treasurer's report showing a current balance of $322.13 was submitted and approved.

Mr. Ware made the following announcements:

That each National TAPPI Member will be receiving a memo from TAPPI headquarters requesting an expression of opinion on whether the national TAPPI constitution can be changed by mail balloting or by those in attendance at the National Convention.

That a questionnaire had been received from TAPPI headquarters relative to the organization of local chapters. Mr. Ware asked that anyone interested visit him and help in the completion of this questionnaire.

JOHN S. SULLIVAN, *Secretary*

Market Research in the Paper Industry

H. O. Ware

I NEED not remind you that this meeting tonight is a TAPPI meeting. It is a meeting of people who are presumably interested in the technical welfare and technical health of one of America's large industries. During the year we have a series of programs which are intended to be instructional. In its barest reality these instructional meetings have two purposes: to help our companies make more money and to help the men who participate in these meetings make more money.

Over the past 40 years the technical personnel have been through a work evolution in which they started as testers and as they grew, added technical control, technical service, product development, process development, and exploratory research to the functions they performed for their companies, with each of these increases in area of activity there has been a corresponding increase in the vitality of the companies employing these men and in the rewards to the men personally. The net result of this transition has been that many technical men in the paper industry have progressed from paper testing to top management. It therefore seems reasonable to conclude that when we collect and bring to the management of our companies the kinds of facts upon which profitable decisions can be made and profitable action taken, we, as members of TAPPI, will become more a part of the top management team.

An area in which the technical personnel have a further opportunity to grow is this thing called market research. By definition, market research is the determination and evaluation of all pertinent facts concerning markets and marketing for management decision and action. By this definition we are not only concerned with the question, how much can be sold at what price and at what profit, but also the question of what elements of this business favor our having a good competitive risk. Some of the business features of a good competitive risk are the facts with respect to the following points:

1. A product equal or superior to any on the market.
2. An existing market or one that can be created.
3. Raw material sources.

H. O. WARE, Beveridge Paper Co., Indianapolis, Ind.

4. A process and a plant.
5. A potential competitive position insured by a suitable manufacturing cost.
6. Patent protection is desirable and often necessary.
7. Competent personnel for the entire enterprise.
8. Continued research and development to maintain the competitive position obtained.
9. A good and understanding management.

If a department in a company were to supply and evaluate the facts relative to these nine points, it would be apparent that they would require a knowledge of the natural sciences, engineering, and economics. They would also deal with sales, production, finance, traffic, research, and development. They would not do, as Bill Dietz expressed earlier this afternoon, travel around an industry asking a lot of silly questions. Those members of TAPPI who become interested in market research and have an opportunity to practice it, may at first, achieve only moderate recognition. However, by the nature of the work, market researchers gain a broad knowledge of all phases of a business and the men who use this experience profitably may be expected to go far in the industry.

I would not hope this evening to indicate to you in more than the most superficial way some of the opportunities for market research in the paper industry. I would, however, like to catch your imagination with some of the typical tools of the market researchers.

Since market research is a fact finding and fact evaluating function of business, it is important to know where to look for facts. The effective use of the literature is of prime importance. Let me point out to you three pieces of literature that I think will serve as an excellent basis for getting you specifically acquainted with the market research activity. These are: (1) "The Chemical Business Handbook," edited by John H. Perry and published by McGraw-Hill; (2) "Chemical Market Research in Practice," edited by R. E. Chaddock and published by Reinhold; and (3) the U.S. Department of Commerce, Bureau of Census, Industry Division, "Facts for Industry."

Since these reference books are expensive, I cannot help you get them but one of the "Facts for Industry" reports is within my economic means and I have taken the liberty of obtaining a copy of this report which summarizes pulp, paper, and board for 1957. I hope that each of you will spend the dollar and purchase this report for your own use hereafter and start down the route of a market researcher, at least in a small way.

If you will refer to page 9 in this report, we will attempt to solve our first market research problem. Let us presume that we are manufacturers of offset paper and last year produced 40,000 tons of offset paper. Our customers have reported very favorably on the quality of our offset paper and in order to expand further, we would have to increase our productive capacity. The first question which must be asked is what portion of the offset market do we currently enjoy. This can be quickly established with sufficient reliability for our present purpose by referring to page 9 under book paper, uncoated, and specifically under offset paper. Here you see our large production of offset paper is only 10% of the potential market and so far our decision to install another machine has a green light. The next step in determining whether or not a machine would be a justifiable decision involves our ability to either satisfy a growing market or drive a competitor out of the business. A plot of "Facts for Industry" reports during the last 10-year period on offset papers will indicate to us whether the offset paper field is growing. A tabulation of our known competitors in the offset field and their production will indicate to us if the total accounted for production of offset paper by known competitors is equal to the "Facts for Industry" figures or if we have overlooked a substantial portion of the offset production. Once we have accounted for all of our competitors, it is now posssible to evaluate them individually and determine if we have a basis for a good competitive risk. At this point we may get involved in an engineering and economic evaluation of ourselves and our competitor.

Many more examples of this kind could be cited but it leads us to another point that I want to get into in the brief period we have for discussion this evening. A responsible market research report would contain the kind of information in an "economic break even curve."

There is one other graphic piece of data which is so fundamental to the market researcher that I believe we should spend one minute with it. This curve is called "the normal growth curve."

By way of summary, let it be said that as potentially successful companies feel the need to broaden their field or overcome innate claustrophobia they will adopt the techniques employed in professional market research. The value of market research as a tool to management has not always been fully recognized. I am hopeful that within a few years there will be a market research division in national TAPPI and that those techniques which are applicable to the paper industry will be disseminated to the members of TAPPI. For each of you there is an opportunity to utilize the market research technique, not only in your everyday work but also to contribute to the welfare of your industry, your company, and yourself.

Presented at the meeting of the Indiana District of the Ohio Section of TAPPI held in Indianapolis, Ind., March 17, 1959.

Delaware Valley

The March meeting of the Delaware Section of TAPPI was held Thursday, March 26, 1959, at the Engineers Club in Philadelphia.

Al Saindon opened the meeting and introduced the guest speaker for the evening, L. A. Moss, paper mill manager of Riegel Paper Corp., Milford, N. J. Dr. Moss' subject for the evening was "Paper Mill Management."

L. H. Smaine, *Secretary*

April Meeting

The April 23, 1959, meeting of the Delaware Valley Section was held at the Engineer's Club in Philadelphia. Following dinner, the meeting was called to attention by chairman Donald C. Kane.

Don Kane called attention to those present that the paper industry in Australia and Africa is flourishing and is technically keeping pace even though mills are not great in number, as yet. Mr. Kane gave his apologies for having to miss so many of the year's Section meetings because of his African tour. He expressed his appreciation to Vice-Chairman Boger and the officers who carried on during his absence.

The nominating committee reported and the slate of officers presented were formally nominated. (The election will precede the May, 1959, meeting, the term of office being the 1959–60 season.)

Chairman—George K. Boger, Jr., Amalgamated Chemical Co.
First Vice-Chairman—Alfred L. Saindon, Jr., Curtis Paper Co.
Second Vice-Chairman—Charles A. Wynn, Jr., Container Corp. of America
Treasurer—L. Henry Smaine, P. H. Glatfelter Co.
Secretary—Thomas P. Czepiel, Scott Paper Co.
Executive Committeemen—Donald C. Kane, Hercules Powder Co.; Carl F. Ackerman, Union Mills Paper Manufacturing Co.

Program Chairman George Boger, introduced the speaker of the evening, Edward Wade of the Sun Chemical Corp.

The meeting was adjourned with a rising vote of thanks to Mr. Wade and his associates from General Printing Ink Co.

P. J. Lovegren

Paper Mill Management

L. A. Moss

THERE is almost no limit to what a well trained, well managed, and well coordinated organization can do if all members work as a team and do not care who gets the credit. Voluntary self denial for the good of the whole organization or team is the secret of most successful operations. A baseball pitcher is usually looked upon as the winner or loser of the game, but he can win rather easily if he is backed up by a fired up team that is playing a tight effective defense and getting hits at the right times. On the other hand, if his team is sloppy on defense and makes errors to allow the opposing team to score and also are not effective at bat, he has little chance of winning even if his pitching is superb. And the team's feelings toward the pitcher can have a powerful effect on the morale and effectiveness of the team, both defensively and offensively.

I like to think of a business organization as a wheel with management as the hub. In its simplest form, it can be a solid one-piece wheel comparable to a one-man business like my barber, Pop Silver, who operates by appointment only in a room in his home that he fitted out for the purpose. By simply sitting down in an easy chair he has, in effect, a mass meeting of his entire organization. There are never any intraorganization communication problems because all interested personnel are always present for all business activities. He recently raised his price and I can imagine that Pop, the laborer, told Pop, the manager, that he wanted more money. Pop, the manager, probably said that it sounded alright to him because he, too, would like more money, but would clear it with Pop, the personnel and public relations supervisor who, being present, proceeded to point out that other barbers were also raising prices so he probably could safely get by with it but it could mean that some family men with several kids might decide this was the last straw and buy a comb, scissors, and clippers to do their own. Then, too, some cheap skate like Al Moss who had been giving him a tip might just pay him the net higher price so there would be no increase. He may have also reminded Pop, the manager, that he did have a high blood pressure problem and a few less haircuts at the higher price to just hold his take the same, might be good business. So without any argument, misunderstanding, or walkout, Pop, the manager, grants Pop, the laborer, a raise and gets one himself at the same time.

In a medium or large business organization, management is the hub only and the various specialized fuctions are as the spokes of the wheel. The hub must hold each spoke firmly in place and in proper relative position with other spokes and the over-all wheel itself so that the wheel can roll smoothly and efficiently on the rim formed and supported by all the individual spokes. Any spoke that is not functioning properly, whether it be too long or too short, too weak or too heavy, will throw the wheel out of round or out of balance so it cannot roll smoothly and efficiently. Corrective action must promptly be taken through the management hub to correct this trouble.

Firm contact must be maintained at all times to allow distribution of stress—communications—to *and* from each spoke relative to the management hub. Secondary distribution of stresses—communications—between individual spokes can and should also take place through the rim of the wheel, but the main nerve center for receiving and distribution must be the hub of management.

Now let's take a little closer look at the make-up of the management hub. It is made up of several layers designed or organized to effectively accomplish its functions. We can think of the over-all Board of Directors as being the basic structural element with the president and executive officer and general manager as the other vital parts held firmly together by bolts which comprise lines of authority and responsibility.

But this wheel is just one of many that serve to support the vehicle that we call our National economy which is owned and operated by good old John Citizen, our favorite customer for whatever product or service we produce. He is the boy that finally cracks the whip. If our wheel fails to give him the results he wants, he always has not just one but many spare wheels in the trunk in the form of ambitious competitors with new or improved products or lower prices. When he takes our wheel off, he is inclined to forget it unless our management hub can take steps through its research and development experts and its efficiency and production personnel—you TAPPI members in the paper industry—to eliminate its defects and again offer improved products and services at lower costs that sales can bring to the attention of John Citizen so he will again make use of our wheel.

I would like to list what I consider to be the major objectives of management:

1. To insure continuity of operation at a healthy rate of growth.
2. To insure maximum return in plant efficiency and capacity, and in product quality from capital investment.
3. To control costs and allow a fair profit return in the competitive market.
4. To produce a quality level equal to, or better than, competition.
5. To maintain a service policy that will satisfy all reasonable customer requirements.
6. To utilize men, machines, materials, and methods for maximum quantity and quality of production at minimum practical cost.

Since no manager can accomplish all these objectives alone in a paper mill, it is a prime function of management to build up an organization of specialists to give the smooth, well balanced functioning represented by our wheel centered around management at the hub.

In order to develop and maintain a good organization, management has several important responsibilities:

1. To create a safe, courteous atmosphere that will enable our employees to make their maximum contribution and derive a real sense of individual satisfaction from each day's work. Satisfaction in a job well done keeps morale high and high morale breeds business success.
2. To get and hold the most desirable employees in order to build an effective organization which will produce and sell a competitive quality product.
3. To make all employees of the company feel that they are part of the team and are so recognized and treated.
4. To develop, through mutual understanding and cooperation, ways and means of continually improving management and employee relationships for the benefit of all.
5. To win the confidence, gain the cooperation and good will of employees, and inspire loyalty to the company and faith in its products.
6. To help employees develop their health and mental ability in their own interest as well as that of the company and community.
7. To develop and practice a kind of industrial democracy and apply the principles of the American democratic way of life to our daily jobs.

These may be high sounding ideals that can never be completely attained but they certainly do represent targets well worth aiming for.

Broad over-all company policy and objectives are normally decided upon by the Board of Directors and are passed along through the various levels of management for execution. The manager at each level must first know and thoroughly understand the company policy laid down by management and also exactly what he and his organization must do toward accomplishing the assigned objectives. Then he must develop his own policies and objectives for his level of operations. He must set goals which are compatable with company policy and make decisions as to methods, organization, equipment, and materials to be used. The goal must be

L. A. Moss, Paper Mill Manager, Riegel Paper Corp., Milford, N. J.

difficult enough to be a challenge but it must also be realistic and attainable since successful attainment of a challenging objective is the best known builder of team morale.

The manager's mission thus is to have the company's policies carried out at the point of operations. He must take orders and he must give orders. He will receive advice from many sources including his staff advisors. He, and he only, will decide what advice to adopt and which to ignore.

To do these things successfully, he must enjoy studying problems, making day-to-day decisions, and in issuing definite and concise orders that leave no chance for misunderstanding. He must set target dates for completion and follow up to see that there are no unnecessary delays. It must not bother him either to give or to receive orders. He must be willing to put pressure on his personnel in an impersonal way without emotional displays. He must be able to give and receive both advice and criticism. He must be able to remain relatively unperturbed by the confusions that almost always result from having at least one boss and several advisors. He must have the courage and insight to depart from the rules when the circumstances warrant. He must be able to manage people—to lead and to coordinate the members of an organization. And he must be willing to run interference for his own subordinates when they need it. This is a big order and all managers do not always completely measure up to it. Some of the weaknesses to guard against are:

A manager may lose his ambition and rely on higher management for all new ideas—he stagnates on the job. He does not learn and grow nor does he contribute as much as he should from his own experience and knowledge. He may lack backbone to stand up for his rights and for the rights of his subordinates. Or he may be just the opposite extreme and greatly irritate the people in higher management levels by unreasonable demands. He may evade responsibility and blame poor performance on company policy but never on his own administrative failures. He may fail to understand that broad company objectives and policy must take precedence over any particular local advantage.

He may become overawed by his own success and try to rest on past laurels or by his conceit lose the good will of his colleagues. Or he may panic when faced by failure and be so emotionally disturbed that his judgment is seriously impaired. Such a situation may develop a phobia and guilt complex that may permanently impair his effectiveness. In one of his poems, Kipling refers to triumph and disaster as "imposters" that should be treated just the same. I am not a great admirer of F. D. Roosevelt but he certainly was a master at expressing thoughts. He stated at the bottom of the depression in 1933 that all we have to fear is fear itself. A manager needs to heed these bits of wisdom from Kipling and Roosevelt.

We can't be flippant and irresponsible to the point of just disregarding our mistakes and failures and just forgetting them. On the contrary, these failures should be unemotionally filed away in our memories right along with our successes as a background of experience to which we can readily refer for guidance on similar problems so that we do not make the same mistake again, but instead make another success. The highest tribute that can be made to any manager or any man would be that he never made the same mistake twice.

In his relationship with his subordinates, a manager must exercise discipline and when a subordinate makes a mistake he must take necessary measures to prevent recurrence. He will be defeating his own purpose, however, if he is so forceful and severe that he scares the subordinate half out of his wits so that in the future he dares not take the responsibility of making a decision for fear of being wrong and getting bawled out unmercifully again. I'm sure you have all seen and maybe even experienced such discipline.

The skill of a manager is difficult to define. He handles many problems on which he can claim no expertness. He makes decisions that involve judgments of experts in many fields; perhaps the doctor, the actuary and the lawyer, or the chemist, merchandiser, and the finance man, and he must rely on their expertness in each field. He reaches his decision by asking a succession of questions that go directly to the heart of the problem.

When the manager has drawn out the answers, oftentimes the decision is obvious. But the end product that is needed, a decision, can be attained only if he concentrates on asking the right questions, in sensing the earliest appropriate moment at which the decision can be crystallized, and then in stating the decision in terms intelligable to all.

There will be times when a manager must have the courage to make his decision contrary to the advice of his advisory experts. In so doing, he loses the security of having staff experts to share blame if it is a wrong decision. It becomes a big risk to take where he shoulders full responsibility—win or lose. But every outstandingly successful man has had to take such risks to get ahead of the field. His superior insight and greater wealth of experience made his judgment reliable, but in many ways it is like a quarterback who throws a long pass on fourth down from his own goal line. He is rated a genius if it is completed for a touchdown, but he is damned to a bench warming job the rest of the season if it fails.

A manager must have the courage to face up to each situation and act promptly and decisively. Management by default cannot meet the demands of modern industrial operations. By prompt action, he will usually be able to nip a problem in the bud before it develops into a chronic ailment that his organization may come to consider as unsolvable. Or he will take a positive approach on a chronic problem and throw in enough talent and skill to solve it once and for all so it does not bounce back again and again for further attention.

Once the decision is made, it must be clearly and concisely stated and delivered through channels to all persons involved in the execution of the decision so that there can be no misunderstanding of its exact meaning and intent.

While on the subject of conferences, I would like to remind you that there is probably more valuable management and staff time wasted in conferences than in any other line of activity, and this is no criticism of conferences as such. They can serve a real purpose, but too often after spending the time, all concerned leave without any concrete understandings or decisions. To be at all worth while, each conference must result not only in a decision but also a well defined program of what is to be done about the decision, exactly who is to do it, when it is to be completed, and, if any costs are involved, a budget must be set up. Only then will a conference accomplish a purpose and not simply lead to another conference.

A manager never has time enough for everything so he must constantly guard against waste of time. He must plan each day's schedule and each week's activities in hopes of fitting in just one or two more items. He must then work by plan allowing flexibility but not fracture. He must discipline himself and refuse to spend time on items of no real consequence. He must force his staff to accept and carry out their full responsibilities so he will spend time on a problem only after the staff has clearly defined the problem and formulated a solution or set of possible solutions.

Also, he must delegate as many responsibilities as he can to his assistants and this in no way means tossing them in someone's lap and forgetting them. He must, in each case, define exactly *what* he wants an assistant to do with everything spelled out in detail so there will be no misunderstanding which will require going back over it again and again. In delegating responsibility, the important thing is to define *what* is to be done but to allow the assistant as much latitude as his experience warrants as to *how* he will do it. This helps

develop the assistant for broader responsibility. By promoting full development of his assistants, a manager is fulfilling one of his most important functions.

This brings us to the subject of communications which is usually a real problem in a big organization. While it is vitally important to provide for prompt distribution of orders and information as to plans, decisions, and policy through channels to all management personnel, and to provide for efficient flow of information from the operating foremen back to top management, it is also most important to develop two-way communications on through to the hourly paid employee. We have tended to neglect this most important part of communications and assume that the working man knows the objectives and problems of the company, and we assume that he fully understands his place in it. We assume also that he knows he is important to operations and that he feels that he is recognized and treated accordingly. Actually, this is far from being true and much costly misunderstanding results.

While we have defaulted in this most important area of communications, other sources of information have been both active and effective in presenting management to him in a most unfavorable light. The best example of this line of teaching is the widespread conviction on the part of the laboring man that the answer to all his troubles is to strike and cause his company so much additional expense, loss in income, and loss in customers that the company will be brought to its knees and forced to grant the demands of labor. In effect, they attempt to kill the goose that lays their golden eggs. They fail completely to understand that such losses leave that much less in the kitty that can be distributed to employees, and it may well hasten the day that operations at a plant may be curtailed and moved to another more favorable location.

You have probably heard spokesmen for labor make statements something like this: "Our members are going to really pitch in and put in 8 hr. of honest, alert work for each 8 hr. of pay and turn out every possible pound of the best paper your equipment can produce, but we will be around again next year to be sure we get every penny we have coming as our share of it."

That, of course, is the promise right after signing a contract but too often there is only lip service to the first part of the statement, whereas, demands for their share can be expected without fail. However, the whole statement honestly made *and* carried out would be perfectly fair to all concerned and can be a guiding principle each of us could do well to follow.

We must work together to create the wealth. Then, and then only, can we fairly be in position to demand and get our share. We can't get something for nothing without stealing it.

We are now faced with a situation where all information from management may be looked upon with suspicion by labor, and we have a long hard fight to gain the full confidence of our labor and have them look to management as their source of factual information. While the responsibility for this rests on top management, all levels of management must share in this responsibility and the program can only be successful when we get all the management team, particularly the operating foremen, thoroughly trained and skilled in handling effective two-way communications. We can be assured that greatly improved labor relations can be the result.

All these people are on our organization team and management cannot stop until ways have been devised to have all members get that good old team spirit to do or die for dear Old Blank Paper Co. Management must provide an atmosphere and incentive to build up the team morale so that it can be more productive. Motivation and morale building can be most rewarding but they require the utmost in patient, careful planning, and administration.

No talk on management would be complete without a word on cost reductions, which can be compared to the pruning of a fruit tree. Judicious pruning of limbs that are defective or serve no useful purpose makes the parent tree stronger and more productive: on the other hand ill advised, excessive cutting can cripple and destory. The same is true of an organization. As materials, equipment, methods, and products change, certain operations and personnel are no longer needed but in prosperous times the temptation is to carry them along and postpone any disrupting change even though such inefficiencies represent a nonproductive additional burden. Under pressure of a recession like the one we have recently experienced, it becomes comparatively easy to make these reductions and then, care must be taken not to go overboard and eliminate vital elements needed for future growth.

Faced with the need for cost reductions, our company made a detailed study about a year ago and found that very substantial savings could be made by rearrangement of work loads and a few equipment changes to reduce labor. Substantial cost reductions were thus obtained almost painlessly and all displaced employees were absorbed in due time as normal replacements of retirements and quits. The results have been beneficial from all standpoints and the program is still being vigorously promoted. For this important job a somewhat longer recession would have been helpful. We found some work loads in our quality control operations that were not full and we considered some reductions there. Our quality control director, however, was able to sell the idea that a reduction was unwise and instead increased the amount of testing in certain areas to provide more effective operation control. At the same time, our research and development department and our engineering department were expanded in operations, personnel, and budget to be ready for healthy company growth in the future. We feel that we saved some money and, at the same time, strengthened our organization.

I hardly need remind you TAPPI members that quality control is a most important function in a paper or pulp mill today, and it is necessary for management to maintain a consistent policy in quality control to insure customer satisfaction and reasonable costs, thus avoiding pendulum swings from over emphasis on quality when a complaint or two come in to over emphasis on production at the expense of quality when the pressure is on for cost reduction. An effective quality control function must have the authority to reject substandard materials. When production people find that borderline quality or less will be passed by quality control, the quality will usually be very slow to show improvement, but when a firm stand is taken to reject everything below a set standard, it is often surprising how quickly the standard that couldn't be met is met. It is unfair to force any operating department to accept substandard quality material and still demand top operating efficiency from it.

Management must set reasonable standards on raw materials and products and demand strict adherence to these standards.

Mechanization and automation for increased production, higher quality, and lower costs do not come to us by chance. They are the product of management thinking and daring. New ideas must be conceived. New money must be risked, and there is no more fertile field than in the paper industry. We can sit back and damn our employees for failure to work, and damn our sales department for failure to sell what we can make but when we honestly analyze our problem, the full responsibility for progress rests with management.

Management cannot sit and wait for better employees and better business conditions. It has a job to do and must get that job done with the available employees and the available equipment under existing conditions.

Presented at the meeting of the Delaware Valley Section of TAPPI held in Philadelphia, Pa., March 26, 1959.

The Getting Together of the Right Paper and Right Ink to Produce Quality Printing

Edward Wade

THE excellent quality of printing produced universally throughout the country indicates that this getting together occurs most of the time. However, when a quality paper is used with an inferior ink, naturally enough, inferior printing results. Also, an ink of good quality, when used with subpar paper, may produce inferior printing, unless specifically formulated for this paper.

Much as a drug store carries a stock line of drugs and cosmetics, and a supermarket carries a standard line of canned foods, inkmakers, too, carry on their stock shelves a standard line of letterpress and lithographic inks. Intended, mostly, for use on single-color presses, these shelf inks are maintained in all popular colors and blacks. Standardized shelf letterpress and lithographic inks are the result of many years of research and development coupled with experience gained in thousands of pressrooms. Formulas of these inks will give working qualities and ink performance of satisfactory nature on the general line of standardized papers currently used by printers all over the nation.

Despite the fact that shelf inks produce good printing and are used in a volume amounting to thousands of pounds a month, requests usually are for small volume print jobs which possess somewhat less rigid specifications than those larger volume print jobs which we will discuss later. Standardized inks are sold to printers in many ways: (1) direct mail advertising, (2) magazine advertising, (3) through ink color books distributed to print shops, (4) direct sales contacts by salesman, and (5) over the telephone. Thus, on a limited basis, we have the getting together of standardized inks and standardized paper to produce quality printing. This successful union, however, represents only a minor percentage of the total paper and ink used in commercial printing because in most cases small volume jobs are involved. Only rarely will a printer attempt to print a volume print job, whether single or multicolor, with shelf inks.

Printing, as we know it, contains many pitfalls into which most printers, one time or another, have stumbled into. Any or all of a list of complaints can develop unless proper care is used in ordering ink for a specific job. These include: (1) improper trap in multicolor printing, (2) mottle or spottiness, (3) poor drying, (4) lack of gloss, (5) offsetting in the pile, and (6) poor match of copy due to lack of color strength.

In order to be certain that he will have the right ink for the paper he intends to use (whether the paper is of the highest quality of possibly a cheaper paper of questionable quality), the printer will most always submit a generous paper sample to the inkmaker for matching purposes. It is important that the following points of information accompany the paper sample and color swatch to be matched:

1. Kind of press the job will be run on. (This helps to determine viscosity requirements for the ink.)
2. Description of the type of forms, whether halftone or solids and their proportions. (This helps to determine needed color strength and drying speed.)
3. Color rotation—what is first color down—what is second color down—etc.? (This helps to determine proper tack differences to assure trap—also tells what colors need be transparent.)
4. Is permanence of bleed resistance necessary? (This helps to determine pigment selection.)
5. Will job be overprint varnished? (This determines the vehicle system requirements to assure proper acceptance of overprint varnish. Also, since the varnish overprint will change the shade of the color, allowance must be made for this in the color matching.)
6. Is gloss wanted? (Special bases and gloss varnishes are needed to produce gloss ink. Also, stock must be suitable for their use.)
7. Will the job require scuffproof qualities? (If so, special hard drying varnishes and compounds need to be incorporated into the ink.)
8. If a multicolor job is to be run on a single or two-color press, how much time will there be between the overprinting of one color on the next? (This determines vehicle system needed—to assure proper drying and scuff-proofness. Also, requires one which will not crystallize and prohibit overprinting.)

These and any number of additional questions and their answers are used to determine the formula to produce an ink which will give trouble-free operation on the press to produce a quality job, on the specific paper submitted.

Thus, if the inkmaker is given all necessary information and applies it correctly and thoroughly, his pigment selection, vehicle system, drying system, and color strength selection will result in a formulation which will give the right ink for the paper. Conversely, if the wrong ink is used, the following troubles may develop:

1. Weak color strengths will cause letterpress or offset halftones to fill up.
2. Solids may mottle.
3. Job may stick in the pile.
4. Weak offset inks may cause scumming or greasing.
5. Improper tack differences may cause poor trapping.
6. Improper pigments may cause fading or bleeding. (This is a common cause for rejection of print jobs.)
7. Improperly formulated nonscuff or hard-dry inks on a job requiring an overprint may not take an overprint color or overprint varnish.
8. Rub off may occur if required scuff-proofness is not formulated into the ink.

Any or all of these difficulties could result in rejection of the job.

If a standard paper is to be used there exists the possibility that a standardized ink formula (such as used for shelf inks) might be used with only minor changes to meet the specific end uses. However, should a cheaper or subquality paper be used, the inkmaker must necessarily experiment with different vehicle systems, and possibly with pigments combinations, too, in order to formulate an ink that will perform properly on the cheaper paper. From an inkmaker viewpoint, inferior papers are characterized by the following:

1. Poor paper surface. Ink drying is spotty—print is not uniform. Half-tones appear uneven and spotty. (a) To correct this condition, letterpress inks can be made more flat to secure a more uniform print or if the stock permits, gloss varnish may be used to hold ink on surface to produce an even print. (b) Should this condition occur in a litho shop, the procedure is to formulate a fast drying, gloss-type ink. In general, it is not possible to make a completely flat litho ink and maintain good lithographing qualities.
2. Surface weak on paper. Normal formulation of ink ruptures surface of stock or picks and eventually, the job will be flooded with "hickies." (To eliminate this, ink viscosity must be reduced and printing quality will suffer. For example, mottle or loss of trap may result.)
3. Paper surface and edges dirty with lint and dust. This condition produces "hickies," probably, one of the most serious problems in litho shops today. (Ink viscosity reduction helps to carry the dirt and dust off the blanket and plate, but printing qualities will suffer from this expedient.)
4. Color of paper off shade or lack of brilliance. This may result in an off color job or seriously reduce the brilliance of the printing.

Conversely, a quality paper possesses the following characteristics from an inkmaker's viewpoint:

1. Paper surface allows production of a uniform print, halftones sharp and clear and gloss holding up evenly and smoothly.
2. Paper surface strong, does not pick and produce "hickies." Also, traps properly.
3. Paper surface clean, with a minimum of dust, lint, and foreign material.
4. Paper brilliant, inks sparkle.

Thus, you can see the necessity of specific ink formulations based on the characteristics of the paper. Also, you can see the need for accurate and complete end-use information in formulating ink for the paper to be used.

Recent trends in both letterpress and offset printing have

EDWARD WADE, General Printing Ink Co. Div., Sun Chemical Corp., New York, N. Y.

been toward faster setting inks with more sparkle or gloss. The lithographers, in particular, are demanding fast set and gloss. While it is possible to build almost instant setting gloss qualities in any litho ink, these features become almost valueless unless the paper is made so as to support the ink. Finish on most coated stocks is adequate, but the job may fail if the paper is not properly made to accept the gloss inks.

Presented at the meeting of the Delaware Valley Section of TAPPI held in Philadelphia, Pa., April 23, 1959.

Following Mr. Wade's presentation, he and C. A. Aloia, conducted an informal session. First, three exhibits were shown demonstrating some of the points covered by Mr. Wade. Secondly, a question-and-answer period followed. Some of the items included are summarized here:

Exhibit 1. A multicolor print job on "good" paper was shown in two parts. First sample was with a "wrong" ink for the job. Second sample demonstrated how the proper ink with the right viscosity gave proper tack for good trap, strong colors, with proper lay-up and gloss resulted in a quality job.

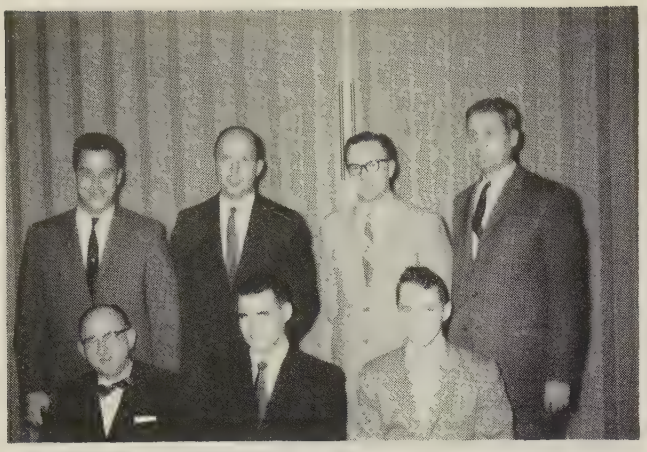
Exhibit 2. A quality photographic portrait was exhibited along with: (a) area magnified 16× which showed some imperfections, (b) another area enlarged to 33× showing poor coverage in some area, (c) halftone area magnified 88× showing some dots with 70, 80, 90, and 100% coverage. Areas of the dots also showed variations in dot configurations, too.

Mr. Aloia pointed out that research is going forward using this means to study ink receptivity. Similar work is going on at Printing Ink Institute at Lehigh and in some European laboratories.

Exibit 3. Simultaneously printed samples of several papers, felt and wire made on a proof press having a solid steel plate printing surface. With careful makeready giving uniform ink coverage on the plate, the samples are printed once. Then, without re-inking fresh samples are again printed in the same areas. (Actual exhibits shown were declared to be somewhat rough due to their being made on a proof press which was not necessarily a precision press as is the one used in the central GPI laboratory.) This method gives a demonstrable measure of smoothness and uniformity of absorption of paper. In using it, the practice is to build each paper sample up to the standard thickness. Thus, even papers of different thickness may be directly compared. Standard samples are built up and may be used for comparion unknowns at any time.

Question: Is a tapered plate ever used with this arrangement?
Answer: No.
Question: How does pH of paper affect the drying of an ink film?
Answer: For letterpress (coated paper) the optimum pH is 7.0 to 7.5 with an 0.5 tolerance. Over 8.0 there is a distinct pigment effect. For the lithographic process the fountain solutions are started at about 3.6 to 3.8. Sometimes with a bleaching effect it may go to 7.0.
Question: How is the pH controlled in the fountain?
Answer: It is usually adjusted to 4.5. When lower than this, complications in drying may develop or plates may be etched. Formerly, acidity was required for the process, but with present-day inks and techniques, there is a definite trend toward weaker fountain solutions. Stripping or scumming, when encountered, may cause an examination of the fountain solution when everything else has been checked. In a well run print shop this is usually corrected as a matter of course.
Question: What is a fountain solution?
Answer: In offset lithography printing the fountain solution is the water that covers the nonprinting areas of the plate. This film must be maintained in these areas only. Then the ink or "grease" film contacts only the image areas, as the film of water prevents ink getting to the nonimage areas.
Question: How is the pH of the paper measured?
Answer: Usually, the surface coating is scraped off, wetted out and the pH of the water measured. Formerly, paper was boiled in water, but this gives untrue values. Actually, it is only the paper surface in which there is any interest in this connection.

Question: In the 60-lb. exhibits (no. 3) could there be thickness differences accounting for the ink receptivity demonstrated?
Answer: Probably, not. It is more apt to be the viscosity factor relating to the coverage.
Question: In the enlargement exhibits (no. 2), could the reason for defects shown in magnified prints be due to the paper surface?
Answer: Yes, it has an effect, but it could also be the plate. Under 88 × magnification no prints are perfect. Also, black is the worst of the colors for the ink.
Question: How does the color effect the result?
Answer: Reds and blues do not have the effect of carbon black. For example, much better inks can be made with synthetic blacks than with carbon black. However, the cost goes up about four times. Due to oil absorption by carbon black, the amount of pigment which can be incorporated in a carbon black ink is about 22 to 25% maximum. For colors 30% is not unusual and with some, as chrome yellows, it may go to 60%.
The magnification technique is used by craftsmen to determine print quality even if only with a hand glass. Without magnification the differences are hard to see.
Research done on the splitting of ink films and rheology studies will help to improve quality.
Question: It is possible that a surface additive on the order of 0.0008% on the weight of the paper could exert an adverse effect on the surface of a sheet being printed with four-color lithography at 1500 f.p.m.? The sheet has no surface sizing nor protective coating and is exposed to gas jets, top and bottom, going into the press. The additive is a powerful humectant.
Answer: It seems unlikely, unless the humectant would cause the paper to take on sufficient moisture that the gas heating could cause localized steam formation resulting in small blisters or wrinkles. This usually occurs only when the moisture content is over 6.8%.
Question: Does low moisture affect the printing beyond the effect of static interference?
Answer: It may cause the paper to be brittle and to tear. A Great Northern Paper Co. customer has found that with moisture in the 5.6 to 6.1% range that a break occurred on the average of one roll in seven, with the same paper in 8.0% moisture range the breaks were only one in a hundred rolls.
Question: What chemical adversely affect the drying of ink?
Answer: Anything which will inhibit oxidation.
Question: How about fluorescent dyestuffs?
Answer: I do not know of any effect, but oxidants should be avoided.
Comment from the floor: Quinoid-type chemicals are in the white dyes.
Mr. Aloia: This might readily cause drying troubles in offset, but usually not in letterpress inks.
Question: Are mineral oils used with pigments in inks?
Answer: Yes, it is used in newsprint inks. There are no good news inks. The volume is large and profit margins are figured in mils. Made of carbon black, viscous mineral oils, and resins, it dries completely by absorption. News inks will always smudge. The reason New York City papers seem to smudge more than in other cities is because of the fast distribution systems, thus there is less time for absorption. The inks and paper are the same for either.
Question: How about colored news inks?
Answer: The difference is mainly in the resin content. Colored news inks contain more resin. Interestingly enough, rosin, usually considered to be a cheap resin, is too expensive for use in news inks.
Question: How can mottle in a print be helped?
Answer: Ink may be either too heavy or too soft. The compatibility of the paper should be matched. If mottle is caused by too soft an ink, increase the viscosity. If too heavy, reduce the tack. The color strength may also be too weak. It is a matter of formulation balance.
Question: Where can a good chocolate colored diaphane flexigraphic ink be obtained?
Answer: Try our Philadelphia, Bensing Brothers and Deeney, Division. If anyone has it, they do.
Question: What printing results are caused by thickness differences?
Answer: It may change the color of the print because of ink volume differences.
Question: Could the paper color influence the hue of the final print?
Mr. Aloia: I recently saw an example of this in a two-page spread in *Sport Illustrated*. The left page looked pink, the right looked blue. Each page had the same 110-line screen illustration work, but the paper color was different and affected the printed result.
Question: Do inkmakers have a preference for paper color between cream white or blue white?
Answer: No, this is up to the customer preference and good



A get-together of some of Ohio TAPPI's officers following the Ladies Night banquet. Seated, left to right, Harlan Vogel, C. G. and E. Co.; Virgil Perry, Harding-Jones Paper Co.; Burton Bailey, Mead Corp.; standing, left to right, Charles Sweitzer, Diamond Gardner Corp.; William Dietz, DuPont Co.; Frank Cessna, Sorg Paper Co.; and Professor Ed Brandon, Miami University

work may be done on either. However, the paper color is considered in matching the ink color.

Question: Is ink ever manipulated needlessly?

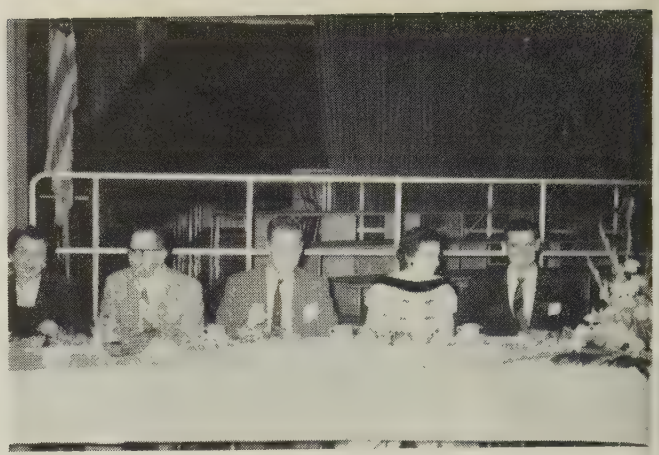
Answer: Yes, and much of it may relate to the old days when inks needed manipulation. With linseed oil bases and heavy inks, much skill was required to produce a quality job to reduce the ink. Today, with high solvent content inks, they are soft and do not require manipulation. In fact, it is one of the most difficult problems a print shop manager has to prevent needless manipulation.

Ohio

About 320 TAPPI members and wives attended the annual Ladies' Night program of the Ohio Section of TAPPI, May 14 at the Hartwell Recreation Center of the Cincinnati Gas & Electric Co. Arrangements were under the direction of Harlan E. Vogel of Cincinnati Gas & Electric. A social hour sponsored by Bauer Brothers preceded the banquet dinner.

After dinner members and guests were entertained by The Cincinnatians, an outstanding men's choral group consisting of some 60 businessmen from the Cincinnati area. They received a standing ovation at the conclusion of their concert.

Virgil Perry, Harding-Jones Paper Co., Chairman Ohio Section of TAPPI, looks on as William Dietz, right, DuPont Co., presents Professor Ed Brandon, center, with a check for $300 as Ohio TAPPI's scholarship for a student in the paper course at Miami University. Professor Brandon is director of Miami University's Pulp and Paper Technology Department



Portion of head table at Ladies Night banquet, left to right: Mrs. Frank Cessna; Frank Cessna, Sorg Paper Co.; Charles Sweitzer, Diamond Gardner Corp.; Mrs. Virgil Perry; and Virgil Perry, Harding-Jones Paper Co.

Dancing followed with music furnished by the Wally Kaye orchestra.

Officers of the Ohio Section for 1959–60 are as follows:

Chairman— Virgil E. Perry, Harding-Jones Paper Co.
Vice-Chairman— Chas. S. Sweitzer, Diamond Gardner Corp.
Treasurer— Ed Suchecki, National Starch Products
Program Chairman— Burton P. Bailey, Mead Corp.
Recording Secretary— George E. Martin, Champion Paper & Fibre Co.
Corresponding Secretary— Stanley W. Trosset, Jr., Diamond Gardner Corp.
Editor— Paul Westfall, Mead Corp.

GEORGE E. MARTIN, *Recording Secretary*

Lake States

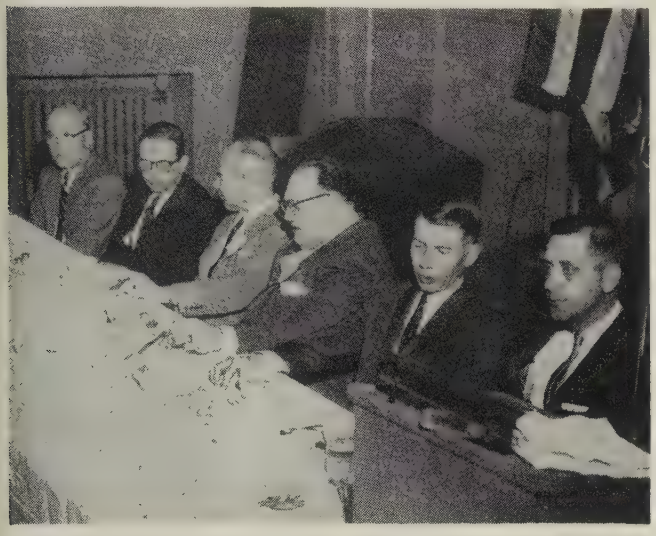
The Lake States Section of TAPPI Engineering Meeting was held on Wednesday, April 15, in Appleton, Wis. S. J. Baisch, chairman for the Engineering Meeting, arranged for plant tours through the Appleton Machine Co., Appleton Woolen Mills, and the Valley Iron Works. The three host plants welcomed approximately 250 members of TAPPI during the afternoon. A good deal of interest was shown in this meeting because of the opportunity to see various pieces of paper machine and converting machinery equipment in

J. M. MacDonald, Jr., V. P. Appleton Machine Co.; F. H. Orbison, Appleton Woolen Mills; P. Boronow, Valley Iron Works; S. J. Baisch, Baisch Associates; L. R. Barlament, Appleton Woolen Mills; Tany Agronin, Appleton Machine Co.; R. S. Bender, Appleton Machine Co.; W. J. Bublitz, chairman, Lake States Section, Kimberly-Clark Corp.; G. E. Reynolds, Valley Iron Works; R. L. Leaf, Jr., vice-chairman, Lake States Section, Shawano Paper Mills; and W. I. Stinger, treasurer, Lake States Section, Marathon Div., American Can Co.

different stages of manufacturing. It also provided for an inside look into the methods of manufacture of paper machine clothing.

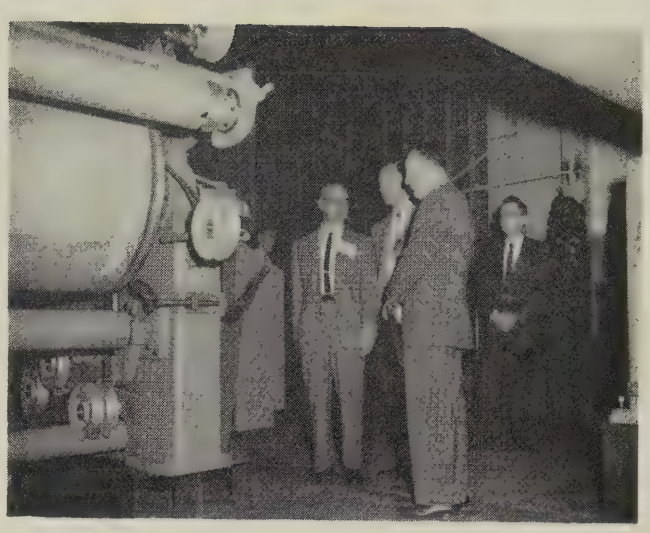
The host companies provided for a social hour at the Appleton Elks Club followed by the regular section dinner meeting. The speakers at the meeting were Tany Agronin of Appleton Machine Co. who discussed some of the activities that the Appleton Machine Co. has presently underway, L. R. Barlament, vice-president manufacturing, Appleton Woolen Mills, who discussed the general problems involved in paper machine felt manufacture, and George Reynolds, chief engineer of the Valley Iron Works, who spoke on the quick wire change method and equipment for the cantilevered fourdrinier. He illustrated his talk with a movie showing an actual wire change. Approximately 200 members attended the dinner evening meeting.

WILLIAM R. NELSON, *Secretary*

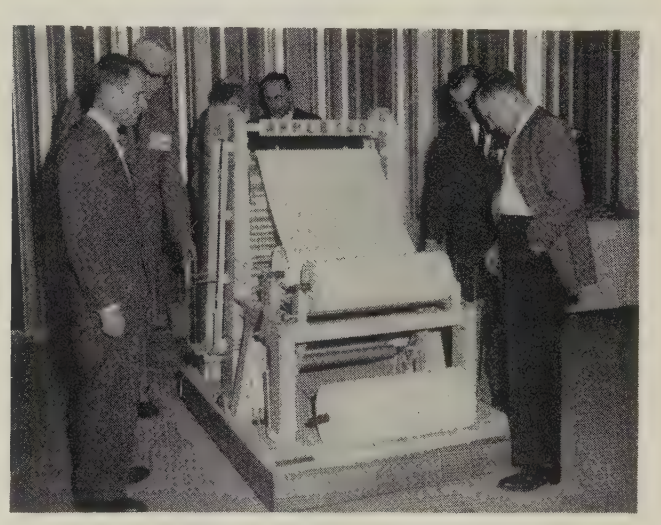


L. R. Barlament, Manufacturing, Appleton Woolen Mills; F. H. Orbison, Appleton Woolen Mills; P. Boronow, Valley Iron Works; Tany Agronin, Appleton Machine Co.; R. L. Leaf, Jr., vice-chairman Lake States Section TAPPI, Shawano Paper Mills; and G. E. Reynolds, Valley Iron Works

W. J. Bublitz, Chairman, Lake States Section, Kimberly-Clark Corp.; R. S. Bender, Appleton Machine Co.; S. J. Baisch, Baisch Associates; J. M. MacDonald, Jr., Appleton Machine Co.; W. I. Stinger, treasurer, Lake States Section, Marathon Div., American Can Co.; and W. R. Nelson, secretary, Lake States Section, Green Bay Paper & Pulp Co.



Paul Boronow, vice president, Valley Iron Works Co., explains new paper machine under construction to visiting Tappi members. Tours of three Appleton, Wisconsin, plants were the highlight of the annual Lake States Section engineering conference



A scaled down supercalender model is demonstrated to TAPPI members attending the annual Lake States Section engineering conference. Pointing out features of the model are C. R. Furminger (left-rear) and J. M. MacDonald, Jr., (right-rear) both with Appleton Machine Co.

TAPPI members touring Appleton Woolen Mills listen intently to Robert L. Barlament (not shown), industrial engineer, explain papermakers' felt operation. Tour of plant was part of annual Lake States Section engineering conference

Italian

On April 9th 1959, the first meeting of the Italian Section was held in Stresa at the Ristorante Regina.

Seventy-five members attended this meeting and the chairman, P. Bersano, delivered the opening speech, informing those attending of the formation of the Italian Section. He also summarized the activities developed in the past as well as the ones under way with a short plan of the work to be done.

Mr. Bersano introduced Adalberto Calvi and Attilio Hintermann, of Cartiere Binda, who delivered a paper on the topic: "Some Aspects Relating to Laboratory Equipment in the Mills."

On the basis of their personal experience the above speakers outlined a general outlook of the methods adopted in the various Italian laboratories, attentively examining the appertaining problems, and concluded stating that the data obtained from the equipment can be seriously affected by the lack of (1) unified methods, (2) initial calibration, and (3) maintenance and repair serivce.

Messrs. Calvi and Hintermann quoted the results of a collective test, such as it is described in the *Tappi* (October, 1958; page 184 and following) with regard to equipments subject and not subject respectively to a periodical calibration.

The above gentlemen suggested that the present Italian Section should be polled, that unified controlling methods, based on TAPPI standards, should be established, and that a service of both calibration and maintenance of the apparatus should be established.

The report was followed with a great interest and the discussion which ensued greatly helped to focus the problem that is really of a keen interest and main importance to Italian mills.

A Committee for Testing Methods has been formed, composed of the following members: M. Adalberto Calvi (Cartiere Binda), M. Sergio Carrera (Corriere della Sera), M. Edoardo Grandis (Cartiere Burgo), and M. Francesco Pancirolli (Stazione Sperimentale Cellulosa Carta e Fibre Tessili Artificiali).

A Committee for Refining Study has also been established composed of the following members: M. Giuseppe Bianchi (Cartaria Ermolli), M. Aldo Mattis (Ente Nazionale per la Cellulosa e per la Carta), and M. Giuseppe Villa (Cartiera Villa).

PIERO BERSANO, *Chairman*

Empire State (Central District)

On May 1st at the University Club in Syracuse the Central District of the Empire State Section of TAPPI had as its guests the Senior Class from the New York State College of Forestry. Our speaker was Ronald W. Hynes of the Newton Falls Paper Co. in Newton Falls, N. Y. Mr Hynes topic was "What Management Expects from Young Graduates." Sixty people attended.

MARIE M. MARTIN, *Secretary*

What Management Expects from Young Graduates

Ronald W. Hynes

PULP and paper enjoys a unique position among American industries with regard to community relations. You who are planning to enter the industry should consider the many advantages offered in terms of satisfaction of living. Because of historical and economic reasons, the production facilities are located mostly in small communities. Some 71% of the communities having pulp or paper mills have a population of approximately 1000 to 50,000. However, 12% of the towns exceed 100,000 in population. Opportunities, therefore, are found in both large and small communities. Of course, urban living appeals to some, but smaller communities offer a serene, full life which some prefer. You may have read or heard these smaller communities referred to as "one-mill" towns, almost primitive. This in reality is untrue: these small communities are clean and charming, surrounded by nature's own beauty—water and woodlands. This combination provides many outdoor recreational facilities, winter and summer.

As you know, the functioning of a pulp or paper mill demands technically trained and educated personnel. These people then are your neighbors in the community, and they provide a stimulating social environment.

What management really expects from you is loyal and intelligent membership on the management team itself. Some of you will eventually direct the management team.

On graduation night as you step up to receive your diploma, be grateful to those who helped you achieve this wonderful moment. This did not become possible only through your efforts—there's Mother and Dad: there are the teachers who make up the faculty of this great college of forestry here in Syracuse. The most important requisite for a happy and successful life is a proper regard for your fellowmen.

When you are being interviewed for your first job, take ample time to explain what you have to offer the company. All too often a wrong impression is created by the applicant who spends too much time on what the company has to offer him along the line of benefits, etc., and too little time on what he has to contribute. Clearly and sincerely outline to your prospective employer what your have to offer as you ask what he has to offer.

While in college you were taught the technical problems with which you were most likely to be faced. However, what you have yet to learn is the application of your knowledge. As you start to work for the average mill, you probably will be one out of ten with technical training and/or a college education. Strangely enough, unless you have the ability to work with men, deal with them, and inspire them to work as a team for you, you will be as helpless as though you had never seen the inside of a classroom. There is a great satisfaction in knowing that you have the ability to be a leader of men—there's an even greater satisfaction in knowing that you are not only a leader of men, but that you can be one of them as you lead them.

Help to educate your fellow worker; he will work harder and better for you. The so-called practical papermaker is really hungry for the technical knowledge you have. You can learn from him as he learns from you.

Encourage his suggestions—don't be aloof. In his own way he feels as important to the company as you, and in his own capacity he is as important as you.

Learn to get along with him at work and at home in your community.

Take an active part in community affairs; take an active part in political affairs.

Strange as it may seem to you, the attitude and behavior of your wife will have an affect on your success, especially in a small community. It is rather natural for the wives to misjudge the importance of their behavior toward the wives of your fellow workers.

Life in the paper field, I assure you, can be wonderful; surely it will never be monotonous. Frequently the college graduate will find that in actual practice there is little, if any, standard progression to higher-level positions. An analysis of the successively higher eschelons of management discloses a wide variety of backgrounds. Advancement is usually based on personality factors, attitude, health, and sucessful work experience, as well as the educational background and field of entry of the employee.

I would like to conclude on this note: "More things are wrought by prayer than this world dreams of." Above all—

RONALD W. HYNES, Newton Falls Paper Co., Newton Falls, N. Y.

each morning as you start the day, take the time to offer a fervent prayer—ask for divine guidance in that you may have the right answers to the many problems which you will encounter throughout the day.

Presented at the Meeting of the Central District of the Empire State Section of TAPPI held in Syracuse, N. Y., May 1, 1959.

Empire State (Metropolitan District)

The following papers were presented at the Nov. 12, 1958, meeting of the Metropolitan District of the Empire State Section.

A Look at Wrought Iron Pipe in the Pulp and Paper Industry

Robert J. Briemont

According to the definition of the American Society for Testing Materials, wrought iron is a ferrous material, aggregated from a solidifying mass of pasty particles of highly refined iron, with which, without subsequent fusion, is incorporated a minutely and uniformly distributed quantity of slag.

More simply, wrought iron might be described as a two-component metal consisting of high purity iron and iron silicate, an inert siliceous slag which is physically united to the base metal. As compared to other ferrous metals, the metalloid content of wrought iron is extremely low. A typical analysis would show the following chemical constituents: carbon 0.02%, manganese 0.05%, phosphorous 0.12%, sulphur 0.02%, silicon 0.10%, iron silicate 2.5%.

The physical properties of wrought iron are largely those of pure iron. However, the strength and ductility are effected to some degree by the amount of incorporated iron silicate or slag and the character of its distribution. The tensile strength and ductility are greater in the longitudinal or rolling direction than in the direction transverse to rolling. This difference is due to the nature of the slag distribution. However, the yield strength of wrought iron is the same whether tested in the longitudinal or transverse direction. ASTM Specification A-72 to which wrought iron pipe conforms requires a minimum tensile strength of 40,000 p.s.i. and a minimum yield strength of 24,000 p.s.i. Wrought iron plate which is manufactured in conformance to ASTM Specification A-42 has a minimum tensile strength of 40,000 p.s.i. and a minimum yield strength of 27,000 p.s.i. As these figures indicate, wrought iron compares favorably in strength to low carbon steel and is considerably stronger than cast iron.

Wrought iron can also be used through the same temperature range as low carbon steel. Like the latter, its strength is a function of temperature, reaching a maximum at approximately 500°F. and thereafter decreasing. While wrought iron is not usually thought of as a high temperature metal, it has been used at temperatures of 1000°F. and higher because of its good resistance to high temperature oxidation.

Unlike cast iron, wrought iron is ductile and can be bent and fabricated either hot or cold with standard equipment. The iron silicate fibers in wrought iron do impart to it certain directional properties, with the result that conventional wrought iron plate has more ductility in the longitudinal direction than the transverse direction. However, special rolling procedures have been developed which permit the production of plate whose ductility in the transverse direction is comparable to its longitudinal ductility. Consequently, there are relatively few items which could not be fabricated from wrought iron plate.

Wrought iron can also be easily welded by any of the commonly used welding processes—such as, oxyacetylene, electric metallic arc, electric carbon arc, and submerged arc welding. Generally speaking, any high quality, low carbon rods are suitable. For gas welding, the rods recommended for welding wrought iron fall within the groups covered by ASTM Specification A-251, Grades GA-60 and BG-60. For metallic arc welding, rods meeting ASTM Specification A-233, Classification E-6010, through E-6013, E-6020, and E-6030 are suitable.

We are frequently asked if there is any danger of galvanic corrosion when wrought iron is welded to steel. The answer is "no." The potential difference between wrought iron and steel is so small that the galvanic effect produced by the union of these two metals is negligent. As a matter of fact, it would be difficult to predict at any given time which of the two metals was anodic to the other; for slight changes in the surface condition of the two could very well cause a reversal of polarity.

As compared to other ferrous metals the most outstanding characteristic of wrought iron is its resistance to corrosion. Corrosion may be simply defined as a destruction of a metal or alloy by a mechanism which is essentially electrochemical in nature. Such a mechanism involves the transfer or displacement of electrons between spatially separated anodic and cathodic areas on the surface of the metals. Such areas exist due to local, chemical, or physical differences in or on the metal itself.

Fundamentally, all efforts to reduce or eliminate corrosion tend to suppress or retard the anodic reaction. There are a number of methods by which this may be done. One way is through metal purification, which reduces the cathodic elements within the metal. A second method is to develop on the metal surface a protective film which isolates the metal from the corroding environments. In essence, the corrosion resistance of wrought iron is related to both methods of anodic control. The purity of the base metal makes it less susceptible to the formation of anodic and cathodic areas on the metal's surface. In addition, the inert glasslike silicate fibers disseminated throughout the base metal act as a mechanical barrier to the progress of corrosion, forcing it to spread uniformly on the metal surface rather than to pit or to penetrate. Consequently, under most environments, wrought iron is able to develop a uniform film of corrosion products. Influenced by the silicate fibers this film is dense and tightly adherent, blanketing the underlying metal and protecting it from the corroding medium.

The corrosion resistance of wrought iron has recently been improved as a result of some 17 years of research. This improvement has been brought about by increasing the deoxidation of the base metal and slightly increasing its phosphorous content, coupled with the manufacture of a more siliceous slag. Test have indicated this improved metal known as "4-D" wrought iron to be approximately 25% more resistant to corrosion than the wrought iron formerly manufactured.

Now that we have reviewed the properties and characteristics of wrought iron we will examine its range of application in respect to the paper industry. Wrought iron has been widely used for both process and nonprocess applications. The latter would include those applications not directly related to the manufacture of pulp and paper. These would include such services as drainage systems, steam and hot water systems, hot and cold domestic water systems, and refrigeration and air conditioning pipe. To these might also be added underground fuel and water lines, smokestacks, breechings, condenser cooling water piping, and condenser and heat exchanger tubing.

In the case of process applications, the applicability of wrought iron is largely dependent on the type of process employed. Wrought iron has been widely used for various applications in the sulphate and mechanical pulping processes. A few of these include black, green and white liquor lines, condensate pipe from evaporators, sludge lines, caustic soda piping, evaporating coils and tubing in multiple-effect evaporators, pulp lines, digestor inlet and blow-off lines, filter vats, and diffusers. Due to the variables in operating conditions from one plant to another, the durability of wrought iron in

Robert J. Briemont, Mgr., Engineering Service Dept., A. M. Byers Co., Pittsburgh, Pa.

these services will vary. However, some outstanding examples have been called to our attention.

At an Ohio paper plant wrought iron plates used in filter vats lasted on the average of 3 to 4 years; whereas, steel plates had an average service life of about 1 year. At this same plant wrought iron pipe used in black liquor, chlorine, and bleach lines was still in service after 15 years; whereas, steel pipe formerly used in these applications lasted about half as long. In another Ohio plant wrought iron was used for stock and bleaching lines. While accurate records were not maintained, the plant engineers reported that wrought iron was far superior to steel pipe in these applications.

Wrought iron diffusers in another plant were still in use after 30 years; whereas, steel diffusers in this installation had an average service life of about 10 years. At a plant in Louisiana, where wrought iron was used for green and white liquor lines, black liquor lines to evaporators, and steam lines to digestors, it was again found vastly superior to steel.

One New England company conducted a test to determine, the suitability of various materials for use in black liquor evaporators. The test liquor consisted of 65% solids and was maintained at a temperature of 110°C. Included in the test were stainless steel, wrought iron, 5% nickel steel, and low carbon steel. Of these materials, wrought iron was second only to stainless steel. It corroded approximately one half as much as the 5% nickel steel and about one third as much as the low carbon steel.

Wrought iron has also been used in connection with the bleaching of sulphate pulp. Caution must be exercised, however, due to the aggressive nature of chlorine and calcium or sodium hypochlorite. Wrought iron is unaffected by dry chlorine but if moisture is present, serious corrosion can occur. Water chlorine mixtures containing large quantities of chlorine would be too aggressive for wrought iron to give extensive service life. By the same token, wrought iron would not be suitable for vessels which are used only for chlorination or for chlorination and neutralization.

As indicated earlier, wrought iron has been used for bleaching lines and has given satisfactory service. However, its selection should be based on the particular operating conditions and the economies involved. In some cases it is more economical to use wrought iron—even though it must be periodically replaced—than to use a more expensive alloy material. By the way of example—a West Virginia mill uses wrought iron pipe to convey calcium hypochlorite solution from a brick-lined tank to paper pulp vats. The service life of wrought iron in this application is approximately 3 years. While this is not particularly long, past experience has indicated that wrought iron stands up far better than other piping materials of comparable price. In still another company, wrought iron is used to handle a sodium hypochlorite bleaching solution. This solution contains approximately 3% free chlorine with a caustic soda alkalinity of 0.4%. Steel pipe previously used in this service lasted only 6 months; whereas, the wrought iron pipe was in service approximately 4 years.

Aside from corrosion, another problem sometimes encountered with bleach solution is that of contamination. Since wrought iron is essentially a ferrous metal, iron ions will go into solution in a corrosive environment. While the extent of the attack may not be severe from the standpoint of piping serviceability, it may be sufficient to over contaminate the solution from the standpoint of product purity. If in any given service, little or no contamination is permissible, no ferrous metal should be used.

In the case of the sulphite process, the use of wrought iron is more limited. Wrought iron is not resistant to calcium bisulphite or sulphurous acid. Thus, it is not suitable for handling the cooking liquors normally encountered in this process. Wrought iron has served certain process applications in sulphite plants. In a number of cases it has been used for target plates in blow-off pits with good results. Wrought iron tubing has also been used in shell and tube exchangers to cool sulphur dioxide gas. Generally speaking, however, its applications in plants employing the sulphite process are confined to the conventional plumbing and heating services.

Presented at the meeting of the Metropolitan District of the Empire State Section of TAPPI held in New York, N. Y., Nov. 12, 1958.

Polyvinyl Chloride Pipe in the Pulp and Paper Industry

John A. Williams

The polyvinyl chloride pipe industry is a young one compared to well-known materials of construction such as cast iron, steel, wrought iron, and the various alloys. Its history in Europe covers a span of 20 years, and installations in the United States have been in service for the past 6 to 7 years.

The industry has continued to show growth since its inception, but a number of factors have influenced the rate. First of all, metal shortages both during World War II and the Korean conflict influenced premature acceptance of all thermoplastic pipe materials available on the market. Producers of compound, manufacturers of pipe, and their distribution outlets had very little factual information about field performance or installation techniques. Standards of quality were not available and the purchaser was forced to depend upon the reputation of the vendor and his own intuition with respect to installation and service conditions of all the materials. In brief some experiences left a number of plant managers or engineers with an almost violent distaste for "plastic" pipe. Many technical associations, such as TAPPI have had first-hand experience in proving the old adage that bad news travels fast. Secondly, for a number of years the sizes, types, and schedules of polyvinyl chloride fittings and other pipe line components were limited in scope. In fact, only recently have a line of molded 6-in. fittings become available. Use of threaded joints precluded uses of lighter schedules such as 40 and the thin wall Schedule A. The vast majority of corrosive service applications would permit use of Schedule 40 with ease except for the joining problem. Thirdly, the fat years of capacity production and the hesitation of responsible plant authorities to substitue a material of probable superior economic life for one of known service life has limited installation of polyvinyl chloride in many instances. Laboratory tests for corrosion, are generally speaking, an excellent screening method for materials, but offer no certainty under field service conditions.

There may well be some of you here, this evening who have experienced one or the other of the outstanding aspects of PVC's middle ages. Let us now examine, a bit our renaissance.

The polyvinyl chloride pipe industry along with other thermoplastic pipe producers have largely recognized the problems and their responsibility to develop standards of quality and performance. In view of the short history of the material in the United States a number of major steps have been taken. Joint Committees of the Thermoplastic Pipe Division of the Society of Plastics Industry and the American Society of Testing Materials are developing material and product specifications. The PVC specification has been submitted to letter ballot. A commercial standard CS207-57 is presently in force. A program of stress testing was sponsored at the Battelle Memorial Institute by the industry. A 3-year program at the National Sanitation Foundation at Ann Arbor, Mich., covered the toxicity, water absorption, extraction, and soil burial tests. A 90-page publication covering the favorable results of these tests has been published. Installation techniques for polyvinyl chloride pipe were prepared by subcommittee members of the SPI PVC group and after approval by the PVC pipe and fittings industry have been made available to all PVC group members of SPI. In addition, technical assistance and information is available from many manu-

John A. Williams, Product Engineer in charge of Thermoplastic Pipe Development, Bolta Div., General Tire & Rubber Co.

facturers. Courses have been run to train trade groups and technical representatives of individual companies, as well as our field sales engineers who promote this product. In short, polyvinyl chloride pipe has taken its place as a reputable material of construction.

Coupled with this is the vastly broadened field of pipe line components. Valves of a number of designs, check valves, strainers, expansion joints, and a wide range of types of fitting, including the drainage variety, are available. Additionally, the ability of polyvinyl chloride, alone of all thermoplastics, to be cemented, machined, welded, and heat formed offers the opportunity for any specialized fabrication, attainable with metal constructions. Socket cement joints permit use of the more economic thinner wall schedules for most services. It must be added, however, that some promotional literature has indicated no skill, care, or technique was required and this type of joint is applicable for all installations. A major chemical company found it desirable to prepare an installation manual for this type of joint. Success was such that only socket cement joints are specified in a companion materials specification. Their use of hazardous fluids and detailed attention to a safety program, testify to the reliability of this joint when properly installed.

Increasing maintenance and replacement labor costs as well as the recent necessity of curtailing operation budgets have made scrutiny of the newer materials mandatory. Hand in hand with this new look is the ability of the earlier producers of polyvinyl chloride pipe and fittings to produce extensive laboratory data on corrosion and allowable working stresses substantiated by field service records covering a span of years. The progress outlined has gone far to promote increasing acceptance by a wide range of industries.

The pulp and paper industry, which you gentlemen represent, is typical of the application potential for PVC. Of all the thermoplastics, quality PVC offers, by generally accepted published analyses, the widest range of acceptable combined properties. They are, corrosion resistance, rigidity, working temperature, working pressure, consistency of performance, nonflammability, errosion resistance, and workability. The material can be machined, threaded, welded, cemented, and heat formed into bends. Companion products of the same material are made in the form of blocks, sheet rod, bar, and hex stock. At present the Byers Type I PVC pipe material handles the following typical paper industry fluids: alum, sulphuric acids to 100%, hydrochloric acid, sodium chlorate, chlorine gas, sodium hypochlorite, and the major piping system in a chlorine dioxide generation plant. Its complete inert nature makes it ideal as a noncontamination material where corrosion is not the major problem. Such uses are evidenced by demineralized water systems for the electronics, power plant, boiler feed water, and photographic developing industries.

Within its temperature and pressure limitations it can replace many expensive alloys and all other thermoplastic materials for the widest range of service. Inventory costs being what they are, the advantages of a single material with adequate piping components readily available cannot be overemphasized.

In closing, we wish to thank you for the opportunity of discussing polyvinyl chloride as a piping material for your industry.

Presented at the meeting of the Metropolitan District of the Empire State Section of TAPPI held in New York, N. Y., Nov. 12, 1958.

Kalamazoo Valley

An afternoon and evening "Printability Symposium" constituted the March 19, 1959, TAPPI meeting at Inman's Restaurant, Galesburg, Mich. The attendance of 178 did credit to the excellent program arranged by W. O. Kroeschell, Michigan Carton Co. It is planned to continue this type meeting as an annual affair since "printability" is of such vital interest to both paper and paper board companies.

The program for the symposium was organized as follows:

Afternoon Session—"Some Factors Influencing Printing Quality"

1. Absorptivity: George R. Sears, Chairman of Graphic Arts Department, The Institute of Paper Chemistry, Appleton, Wis.
2. Surface Configuration: Raymond L. Janes, Assistant Professor of Paper Technology, Western Michigan University, Kalamazoo, Mich.
3. Compressibility: A. Tom Luey, Executive Secretary, Boxboard Research and Development Association, Chicago, Ill., and Kalamazoo, Mich.
4. Movie: Ink Film Splitting: Narrated by J. F. Steinbruner, Plant Manager, Interchemical Corp., International Printing Ink Div., Chicago, Ill.

Evening Session—"Direct Tests for Evaluation of Printability"

1. Paperboard: Clyde G. Eckhart, Development Chemist, Ohio Boxboard Co., Rittman, Ohio
2. Paper: Walter W. Roehr, Senior Research Associate, Kimberly-Clark Corp., Neenah, Wis.

A "Question-and-Answer" period following the afternoon session was recorded for publication.

In the evening session, Dr. Roehr pointed out that in gravure printing, the highlight areas frequently appear broken due to lack of proper ink transfer caused by some cells not printing. Using slides, Dr. Roehr demonstrated several types of rotogravure etching and explained how grainy high lights are caused by the failure of the depressed ink surface in the center of the cell to contact the paper.

The properties of paper that have a bearing on graininess of rotogravure high lights were said to be surface smoothness, compressibility and flexibility.

April Meeting

The April 23, 1959, meeting of the Kalamazoo Valley Section of TAPPI was held at Inman's Restaurant, Galesburg, Mich. Otto Berggren, field service engineer for the Huyck Felt Co., was introduced by W. O. Kroeschell, Michigan Carton Co. as the guest speaker.

The application of the beta ray gage to the measurement of water removal in the press section of paper machines was discussed by Mr. Berggren and was demonstrated with the use of slides.

May Meeting

The Annual Recognition Night for the Department of Paper Technology, Western Michigan University, held May 14, 1959, at the Harris Hotel, was the final meeting of the 1958–59 season. Richard T. Trelfa, chairman of the APPMSA, presided over the meeting attended by 117 members of TAPPI and APPMSA.

The late officers for the 1959–60 season as proposed by the Nominating Committee, H. R. Hall, chairman, was unanimously accepted by the membership:

Chairman: W. O. Kroeschell, Michigan Carton Co.
Program Chairman: P. D. Graham, E. I. du Pont de Nemours & Co.
Secretary: W. L. Kite, Lee Paper Co.
Treasurer: J. D. Chadderdon, The KVP Co.

The Past Chairman's Certificate was presented to E. E. Stephenson, Sutherland Paper Co., by H. R. Hall for 4 years of outstanding service to the local section. Mr. Stephenson will continue as a member of the Executive Committee.

R. M. Levy, Allied Paper Corp., was appointed to the Executive Committee for 1959–60, replacing L. D. Nicholson, Hamilton Paper Co.

The membership unanimously accepted the new Articles of Organization written by W. O. Kroeschell with the sanction of National TAPPI and presented by E. E. Stephenson.

An honorary membership in the Western Michigan University Alumni Association was given Olin W. Callighan for his

outstanding services throughout the years to Western Michigan University and the Alumni Association, by Wilbur Noel.

A set of TAPPI Standards and Data Sheets was presented to William Pritchett, as the Senior Student Award for 1958–59, by Wilbur Noel.

Three Kalazmazoo TAPPI research awards, amounting to $100, $60, and $40 were presented by E. E. Stephenson to Earl Malcomb, Thomas Elias, and Uldis Ievans, respectively, for presentation of the most outstanding papers among the students of the Department of Paper Technology, Western Michigan University. Those present at the meeting were introduced to the group by Alfred H. Nadelman, head of the Department of Paper Technology.

It was announced by G. J. Gill that the Annual Joint Fun Day will be held June 23 at Gull Lake Country Club.

Tribute was paid to A. A. Coffin, who has announced his retirement from Titanium Pigment Corp. after 35 years of service to the paper industry.

P. Dean Graham, *Secretary*

Surface Configuration of Paper and Paperboard and Its Measurement

Raymond L. Janes

This paper is concerned with (1) the implications of the term "surface configuration"; (2) the significance of surface configuration to printing; and (3) a critical analysis of the attempts that are being made to measure surface configuration.

I am sure that we all appreciate the fact that the printing quality of paper and paperboard is a complex function of such factors as surface configuration, compressibility, ink receptivity, and ink absorption. Furthermore, we recognize that these factors are so interrelated that their contributions to printing quality change with printing and ink conditions. Today, in spite of good strides in the last decade, we are not as yet able to isolate these variables so that their separate contributions to the printing mechanism can be quantitatively evaluated. Until we can do this, we will be handicapped in our attempts to control and improve the printing behavior of our papers. It is with the above in mind that this afternoon's program has been planned, in an attempt to "clear the air" and present our state of knowledge in the areas of absorptivity, surface configuration, and compressibility.

This evening, the alternative approach to arriving at a measure of printing quality will be discussed; that of proof pressing and actual controlled printing.

You will note that I have avoided the use of the term "smoothness." I prefer the term "surface configuration" because, to me, paper "smoothness" has meaning *only* in terms of the methods used for its evaluation. Smoothness is not a fundamental or even definitive property of a paper surface because it cannot be correctly expressed in terms of a single value. In contrast, the term "surface configuration" correctly implies that we are concerned with the geometry of a surface and not just a point value. Actually, to meaningfully describe a paper surface we must describe (1) the height, depth and width of the surface variations, and (2) the frequency and distribution pattern of these variations. This cannot be done with one value as in the case of the majority of the "smoothness" testers. Consideration of the above statements explains why we often observe two papers of identical "smoothness" value printing differently, even though their other properties are similar. This also explains why difficulty is often experienced in correlating the various instruments with one another for various types of papers. A paper possessing numerous, small surface irregularities will generally print better than a paper containing fewer, though larger, deviations; both papers might well exhibit similar "smoothness" values.

It is difficult to separate surface configuration and paper compressibility (change in thickness with pressure) during printing. It is generally recognized that relatively rough papers can be printed with good fidelity provided their structure permits their conforming to the plate surface during pressure application. Thus, a rough paper can have good "printing smoothness." However, even-surfaced paper of similar compressibility would normally print with even greater quality. The relative importance of surface configuration would be expected to change with the printing process and conditions as well as with the type of paper used. One may ask, is the better surface gained by heavy calendering neutralized by destroying the paper's bulk and compressibility?

Raymond L. Janes, Paper Technology Department, Western Michigan University, Kalamazoo, Mich.

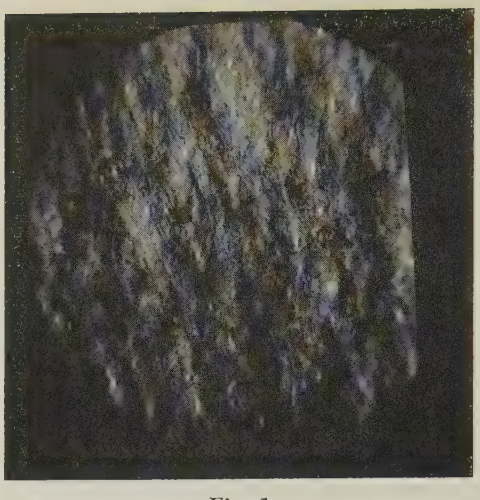


Fig. 1

EFFECT OF SURFACE CONFIGURATION ON PRINTING

Our goal in printing in addition to making a profit is to reproduce the customer's copy with high accuracy. The degree of surface levelness we require depends on the particular job and the printing process itself. None of the processes can produce fine halftones on very rough paper. The offset lithography process is the least critical as a result of the compressible, conforming nature of the rubber blanket cylinder.

Gravure is the most critical process in demand for good surface uniformity because in halftone work the individual cells have no way of emptying completely unless direct, full contact is made with the paper surface. In less severe cases only portions of the cells print, yielding a grainy halftone.

In letterpress printing we can improve printing quality partially by printing with greater pressures or with thicker ink films. However, high pressure may cause excessive "squeeze-out," embossing and mottling, and heavy ink loads lead to filling up between dots and low ink mileage. The best printing fidelity is obtained with a "kiss" impression and thin ink

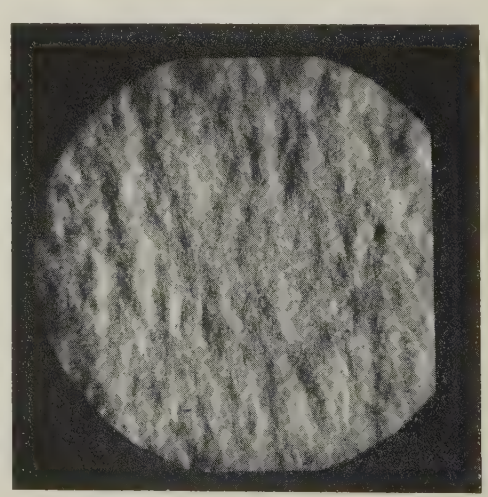


Fig. 2

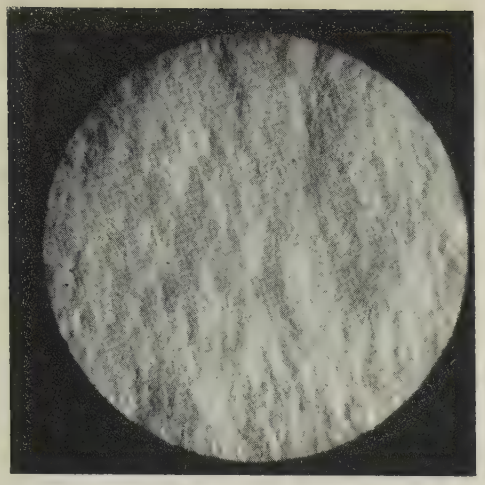


Fig. 3

films. These necessitate an excellent paper surface profile and adequate compressibility.

EVALUATION OF SURFACE CONFIGURATION

Gross surface nonuniformities such as wild formation, crush marks, galvanizing, etc., are best observed and controlled in most mills by visual inspection under oblique lighting which serves to accentuate the imperfections. The evaluation obtained in this way is subjective and dependent on psychological factors; e.g., a sheet with a high gloss will be ranked "smooth," although the surface as seen by the printing impression may be "rough."

The smaller surface variations, such as coating pattern, interfiber voids, and felt and wire marks are measured either directly or indirectly by the following techniques:

1. Air Leakage Instruments
   - A. Bekk
   - B. Gurley and Gurley S.P.S.
   - C. Scheffield
   - D. Bendtsen
   - E. Williams
2. Optical Contact Area
   - A. Chapman
3. Ink-Oil Transfer and Coverage
   - A. Proof press techniques
   - B. Hull-Rogers drawdowns and wipes
   - C. Nip-oil-spreading apparatus
4. Surface Profile Measurements
   - A. Brush Surface Analyzer
   - B. Proficorder
5. Subjective Evaluation of Magnified Surfaces
   - A. Visual
   - B. Photographic
   - C. Scheid tester

As we consider the various techniques and instruments for evaluating surfaces we must bear in mind:

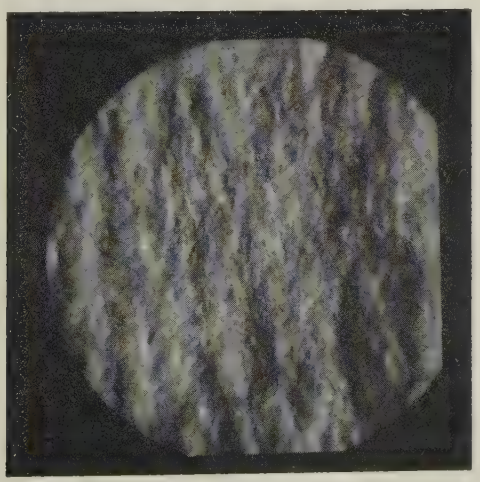


Fig. 4

Fig. 5

1. Single-value results are dangerous in that they are biased averages of a surface. The results will be meaningful only for ranking of very similar paper surfaces for control purposes. The results cannot be expected to correlate very well with printing behavior because printing is affected by the individual imperfections and *not* by an instrument average.

2. The value of any instrument is based on (1) whether it practically predicts and ranks surfaces as they will relate to printing fidelity, and/or (2) whether the instrument is dependable for use in controlling manufacturing variables. On the basis of these criteria, few of the techniques correlate very well with printing fidelity, but most will serve for control during the manufacture of similar grades.

1. Air Leakage Instruments. These instruments yield one-value, indirect measurements of surface irregularities by noting, with various techniques, the rate of air passage through the voids formed between a paper surface and an optically flat surface. The instruments differ in design with respect to air pressure, contact pressure, and the geometry of the flat surface in paper contact. Poor to good correlation has been shown with printing within one grade of paper (*1*). Generally, these instruments are adequate for control purpose within a grade, and have the advantages of simplicity and ease of operation.

Most air-leak instruments use relatively low contact pressures, but pressures approaching those of printing have shown promise of better correlation, although one instrument showed lower correlation at higher pressures (*1*).

We must keep in mind that air compared to a printing ink film on an impacting plate will not be affected similarly by the same surface imperfections. Surface irregularities are weighted to the 4th power of their radii with the air leakage testers. This places inordinate emphasis on a few large imper-

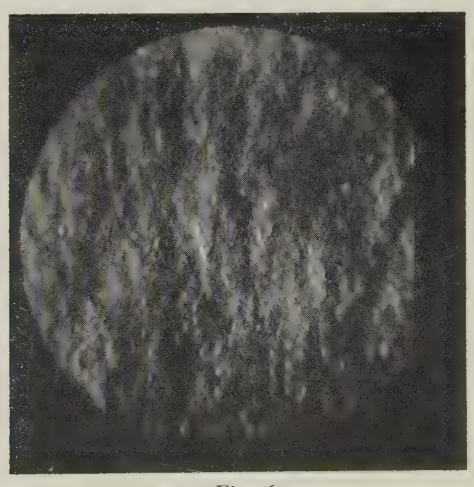


Fig. 6

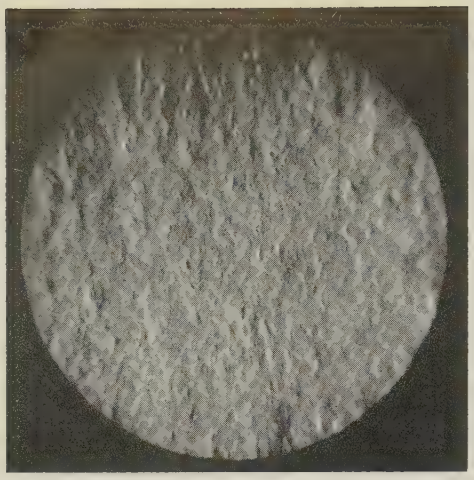


Fig. 7

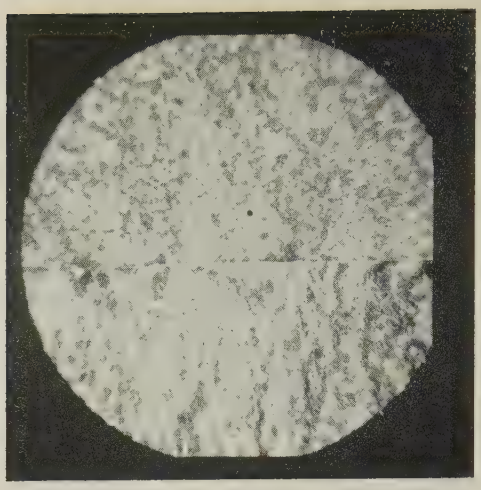


Fig. 9

fections and accidental particles that may be in contact with the flat surface of the instrument. Furthermore, with smooth papers, some of these testers are high in error because of the larger amount of air passing laterally through the sheet itself.

2. The *optical contact area* instrument of Chapman (*2, 3, 4*) is an attempt to measure smoothness under pressure, which many felt would more closely reproduce printing smoothness by accounting for surface configuration and compressibility simultaneously. This instrument facilitates the pressing of a specially designed prism against the paper sample at various pressures. A beamed light, reflected from the paper and through the prism at two different angles, is measured photoelectrically. Based on the law of refraction, different amounts of light produce different photoelectric readings at the two measuring angles. The difference in readings is related to the fraction of the paper in optical contact. The amount of surface in contact, as well as the total surface, can be observed visually or photographically, and the change in contact pattern noted with pressure. It is common to observe different patterns of areas-in-contact for papers having the same Chapman reading, again illustrating that more than one value is necessary to characterize a paper surface.

The Chapman instrument has proved of value in interpreting surface profile and static compressibility relationships with various materials, but it has generally fallen short of providing good correlation with actual printing performances. Two possible flaws in the instrument are (1) that optical contact is not needed in printing because we have a fluid ink film present, and (2) it measures surface in contact at equilibrium pressure whereas printing pressures employ dynamic forces. Generally unsuccessful efforts have been made to incorporate various fluid films in the Chapman to simulate an ink film. A good dynamic compressibility test does not exist to the writer's knowledge, nor has a need been definitely proved. In this connection, these pertinent questions come to mind: (1) Does a surface under dynamic forces correspond to the same surface under static-equilibrium conditions? (2) Does free surface configuration have any correlation with the surface pattern under dynamic pressure?

3. The *measurement of ink transfer and coverage* by means of a proof press under careful control of ink film thickness, pressure, and rate of printing is in my opinion the best and most direct laboratory approach to evaluating the combined factors of surface configuration and compressibility. Various techniques (*5, 6, 7*) have been worked out for evaluating surface coverage both in solid and half-tone copy, but many of them are time consuming and/or subjective. Reflectance and gloss instruments are often blind to the pattern of ink distribution.

Zettlemoyer and Fetsko (*9*) related ink transfer on a proof press with print quality of solid areas and obtained a useful constant related to the contact between the paper surface and ink which they called "printing smoothness."

The *Hull-Rogers drawdown techniques* (*10*) employ a series of three ink drawdown and wipe tests to measure both large and small surface contour variations of paper. The tests are simple but difficult to interpret since they are all subjective. The rigid blade drawdowns evaluate large imperfections like formation streaks; the flexible blade drawdowns show medium surface imperfection such as coating pattern, wire marks, etc.; and wipe tests indicate penetration and very fine surface structure. These tests appear to be valuable tools in experienced hands in that they recognize that surfaces cannot be evaluated in terms

Fig. 8

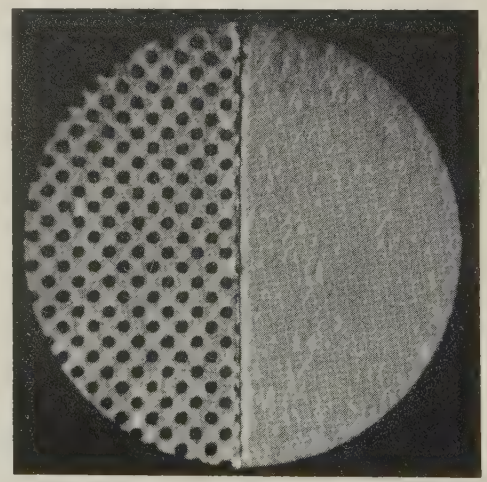


Fig. 10

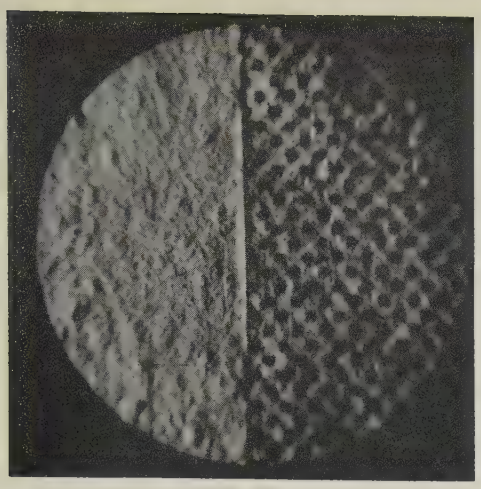


Fig. 11

of one value. Excellent correlations with actual printing have been observed.

Wink and Van den Akker (*11*) presented a new technique for spreading a liquid film on paper by means of a dynamic pressure-nip technique, and mathematically related the oil pattern formed to a surface roughness index and an initial permeability factor of the surface to oil. A further report of this technique was given at the 1959 National TAPPI Meeting.

Work is being carried out at Western Michigan University under the direction of R. A. Diehm in an effort to utilize the I.G.T. instrument to measure printing smoothness. Halftones of various percentages of etch and lines per inch are incorporated on the printing disk. Printing is done at various pressures at constant ink film and the printing quality evaluated numerically by a halftone analysis technique. The pressure needed for excellent fidelity will be related to printing smoothness.

4. The measurement of a paper surface contour with the Brush Surface Analyzer (Brush Electronic Co., Cleveland, Ohio) is probably the most fundamental approach to determining the exact size and distribution of surface imperfections. The only problem here is to interpret and relate the readings obtained to actual printing performance. Roehr (*12*) described the use of the instruments and the modifications made to yield meaningful data. The instrument utilizes a piezoelectric crystal which generates a voltage proportional to the vertical motion of a diamond tracer point as it is moved over the paper surface. A calibrated amplifier magnifies the voltage output and activates a direct-linking oscillograph which traces the pattern on a moving graph paper from which readings may be made directly. Roehr designed an automatic

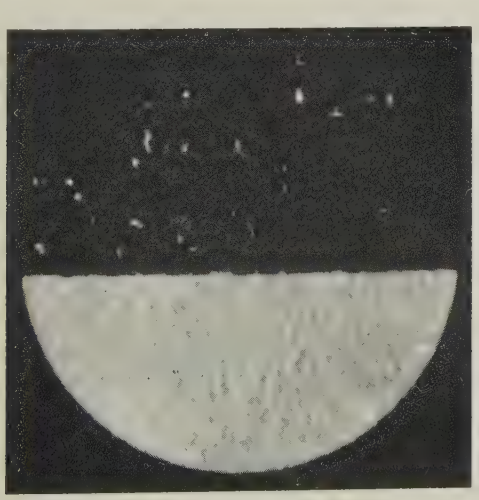


Fig. 12

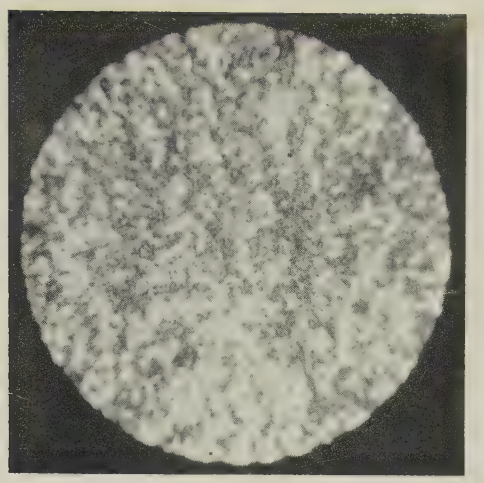


Fig. 13

counter which contained only imperfections above a certain magnitude. Means were incorporated for calculating the per cent of the sheet surface area below 225 microinches. This value was found to correlate 0.75 with actual printing observations on coated papers. With white patent coated news, however, Fetsko (*1*) obtained a 0.41 correlation coefficient.

Brush profile studies by Barber (*13*) have shown that the size and shape of surface irregularities rather than the average roughness is of much greater effect on printing fidelity. The problems of skipping and deformation of halftone dots are dependent on high, sharp peaks and deep, narrow valleys of the paper surface. Broad peaks and valleys have considerably less effect. The writer feels that this is an excellent analytical technique for studying paper surfaces and that more work should be carried out to study the relationship of free surface configuration and so-called "printing smoothness." The frequency response characteristics of the piezo crystal-stylus point combination have been criticized, and the actual surface plot, thus, is said to include some distortion.

The Brush Analyzer appears to offer little promise for control work because of its delicate nature and relatively high cost.

The use of a similar instrument, the Proficorder, is described by Hull (*14*).

The *Scheid tester* conveniently measures the light beam angle at which the resolution of surface irregularities sharply decreases as the incident beam angle is decreased from 90° toward the normal. The more regular the surface the less change in angle from 90° that is needed to cause a sudden decrease in resolution. This test suffers from being a one-value determination and possessing a different type of endpoint for coated and noncoated grades. It has good properties for control purposes and seems to rank imperfections of related surfaces very closely to the Brush Surface Analyzer.

5. Subjective Evaluation of Magnified Surfaces with Oblique Illumination. Many laboratories are presently using oblique illumination of from 1 to 5° and microscopes for studying the nature of the surface variations of their papers. At this year's National TAPPI meeting, R. O. Ragan discussed a compact unit for making photomacrographs. Photomicrographic cameras are also available.

Using Ragan's technique and a panel of 10 perons for subjective evaluation of the surface photomacrographs, Fetsko (*1*) obtained better correlation with printing smoothness than exhibited by any of the previously mentioned methods. The following correlation coefficients were obtained:

Surface photomacrographs	0.77
Air leakage tester	0.13 to 0.64
Chapman	0.41
Brush profile and Scheid	0.62

Surface photographs can be misleading, however, unless extreme care is used to select a representative area of the surface.

Such a small area is photographed that one can obtain rough and smooth appearing surfaces from the same sample. The surface photographs must be evaluated subjectively, but this is better than a single-point evaluation. The photographic techniques record and reveal the magnitude of variations in surface imperfections as well as their distribution. All that is required is skill in interpretation and careful sample selection. For control purposes, comparison can be readily made from day to day and kept in line with standard sample photographs.

The accompanying photographs indicate the nature of the surface photomicrographs that can be obtained with the Central Scientific Co.'s Polaroid setup.

The pictures were made using Type 46 Polaroid film which yields positive transparencies directly. The linear magnification is 10×. The light source was directed across the machine direction at an angle of one degree to the paper surface.

Figures 1, 2, 3, and 4 are all white patent coated boards in the order in increasing printing quality as evaluated commercially. One notes that the subjective surface levelness is in the order of 3, 1, 2, 4. This indicates that surface configuration is not the only factor in printing behavior.

Figures 5 and 6 are photomicrographs of different areas of the same sample. This points up the importance of selecting a representative area for this type of work. Indications are that it is most meaningful to photograph the worst areas, because these are the ones that are most likely to print poorly.

Figures 7 and 8 are photomicrographs of boards coated lightly by the Champion process. The sample in Fig. 7 required 7 points of impression, whereas Fig. 8 needed 12 points in order to obtain equivalent half-tone fidelity in half-tone printing.

Figure 9 shows a photomicrograph of two boards both of which have been printed in a solid red. There is an obvious difference in ink coverage.

Figures 10, 11, 12, and 13 show halftone and solid microphotographs of two grades of paper. The sample dipicted by Figs. 10 and 12, of course, indicates much better detail of halftone and better ink coverage than the sample in Figs. 11 and 13.

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Presented at the meeting of the Kalamazoo Valley Section of TAPPI held in Galesburg, Mich., March 19, 1959.

Effects of Board Compressability on Printing Smoothness

A. Tom Luey

In discussions of printability and printing smoothness the effects of compressing the sheet are frequently mentioned. It has been thoroughly demonstrated that as a sheet is compressed its smoothness will improve and the extent of the compression is a very important variable in the printing process.

A. Tom Luey, Executive Secretary, Boxboard Research and Development Association, Chicago, Ill., and Kalamazoo, Mich.

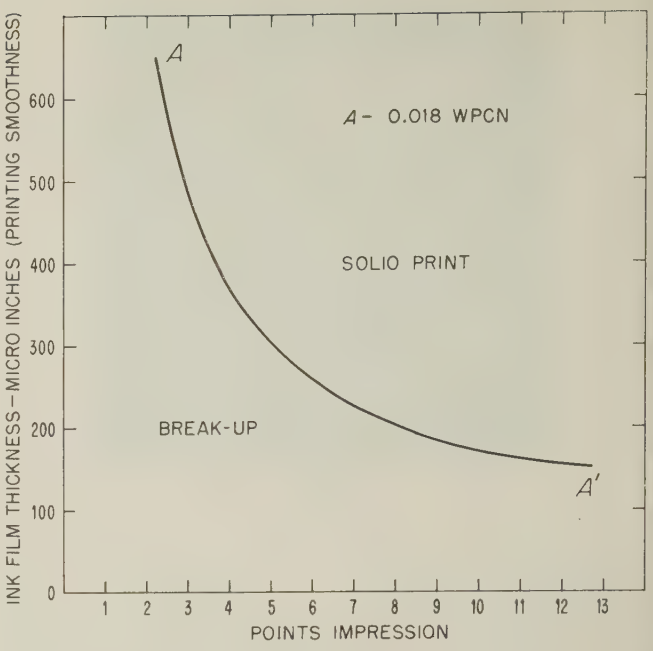

Fig. 1. Printing smoothness versus impression

Because of the large effect of this compression variable on the printing smoothness, it would appear reasonable to suspect that variations in board quality that affect its compressibility would be of importance. Or to re-phrase it, the coefficient of compressibility of the sheet is a variable that we may expect to affect the printing smoothness.

Let us assume for the moment that this is a valid assumption. The next question would then obviously be: "What is the relationship between variations in compressibility and printing smoothness?"

In order to answer this question it is necessary to examine the fundamentals of the printing process involved and make some relatively simple experiments in printing.

During the printing of boxboard by the letter press process the board is squeezed between the plate and the impression cylinder. This squeezing action, or compression, results in improving the smoothness of the board to a marked degree. This can be illustrated by carefully controlled printing tests on a Vandercook with a fixed bed plate in which the ink film thickness and amount of compression or impression are varied over a considerable range. As the impression is increased the ink film may be decreased and still produce a solid print without break-up. This is illustrated in Fig. 1.

If this test is carried out on a variety of boards we will obtain a different curve for each sample lot tested. The curves will be basically similar in that the improvement in smoothness appears to be fairly rapid in the low ranges of compression, then it slows down and reaches a minimum value which is not changed by further increase in impression.

The level at which the smoothness curve bottoms appears to correlate with the minute surface characteristics of the board. If the top liner is made of 100% bleached kraft which is a relatively large, coarse fiber, the curve will bottom near 320 microin. A top liner of bleached sulphite, soda plus a clay filler will bottom near 200. Clay coatings will reduce this still further.

The steepness of the left side of the curve appears to correlate with the large surface irregularities, such as wire and felt marks. A very smooth, level sheet will produce a relatively flat curve.

The curve A-A′ represents the minimum ink film thickness required to print a solid without any break-up at the points of impression indicated. The ink film thickness is taken as a measure of the "printing smoothness" at the impression indi-

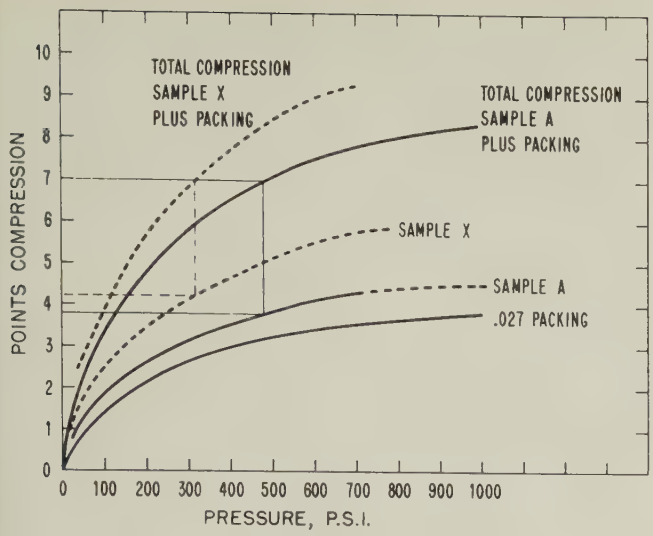

Fig. 2. Pressure-compression data

cated, since there can be no depressions in the sheet of greater magnitude than the ink film thickness.

If we wish to determine the actual compression of sample A in the experiment we must take into account the compression of the tympan paper or packing. The results of pressure-compression studies of the sample and the packing paper are shown in Fig. 2.

By referring to Figs. 1 and 2 we can determine the printing smoothness of sample A at definite amounts of compression of sample A only. This is shown in Fig. 3.

It should be emphasized that the preceding comments are based on the printing of solids only. One may use this information to predict the results in printing a combination solid and halftone plate in which the halftone is recessed, say four thousandths. The boards with relatively flat and low curves will obviously give the best results.

It has frequently been theorized that the compressibility characteristics of the board would influence its printing characteristics. It was felt that some boards would deform more readily during compression than others; that they were more plastic or yielding in their construction or materials; and that still other boards could have a relatively hard, unyielding surface. Based on this theory, two sheets of identical appearance and with the same fiber size distribution in the top liner could have substantially different printing characteristics.

Also shown on Fig. 2 is sample X, which is taken to be identical with sample A in all respects except that it is 33⅓% more easily compressed.

During printing the total compression of sample A plus the packing will be the same as sample X plus the packing. If we take this to be 0.007 in. or 7 points, then we can determine that the compression of sample A will be 3.8 points. Sample X will be compressed 4.2 points.

Reference to Fig. 3 will show that the difference in smoothness that will result from this is only 15 millionths of an inch.

A similar set of calculations using the quantity of packing papers necessary in a commercial press (which is approximately double that used in the example above on a Vandercook) will show an increase in smoothness of 20 millionths of an inch.

The letter press printing operation tends to minimize the effect of variations in compressibility. This is due to the fact that the printing takes place under conditions of fixed impression, not of fixed pressure. Although the difference in compressibility of the samples was 33⅓%, the net increase in compression was only 10%.

We can complicate this picture a bit more by speculating on the relative compressibility of the filler and liner stock. If the increased compressibility of sample X was due to the filler stock only, we would not expect to obtain the improvement in smoothness indicated. Probably the converse is true.

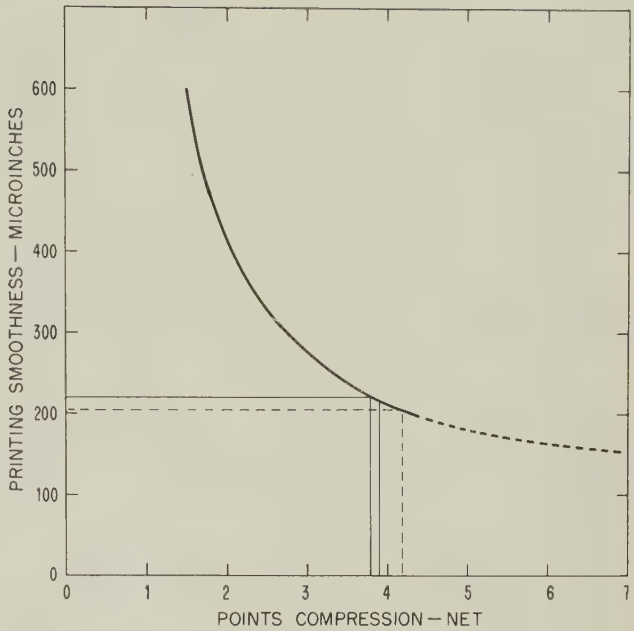

Fig. 3. Printing smoothness versus net compression of board

Although we know relatively little about compressibility and factors affecting it, we do know that to obtain a 33⅓% change in the physical qualities of a sheet requires a substantial effort. It is questionable at this time if an improvement in smoothness of 15 millionths of an inch would justify it.

This is particularly so since there is evidence that the original free state smoothness of the board will have a tremendous effect on the printing smoothness.

If we examine a variety of samples and obtain data of the type shown in Fig. 1 it can be shown that the printing smoothness, or ink film requirements, can be related to the original smoothness of the board (before compression) and the amount of impression applied. The board characteristic that appears to be involved is the original smoothness or roughness.

Further, the Scheid smoothness test, which is a measure of the roughness of the free surface by a visual technique, correlates closely with the printing smoothness characteristics of the sample.

From this, it is my conclusion that the variations in compressibility of boxboard have little effect on its printing smoothness.

Presented at the meeting of the Kalamazoo Valley Section of TAPPI held in Galesburg, Mich., March 19, 1959.

The Savings of a Routine Printing Smoothness Evaluation Program

C. G. Eckhart

Much has been written and said recently about the printability of paperboard and the associated variables of this aspect of graphic arts. Printability is a generic term which covers a lot of area, but basically refers to the faithfulness of reproduction compared to the original copy or illustration. The printing smoothness of board, therefore, is but one of the inherent variables contributing to printability along with the ink, press, printing process, environment, etc. We would like to describe to you how a printing smoothness evaluation program on board has saved us money not only in the folding carton plant but in the mill as well.

DESCRIPTION OF TEST PROCEDURE

We have previously reported our printing smoothness test

C. G. Eckhart, Development Chemist, Ohio Boxboard Co., Rittman, Ohio.

(*1*), but in order to give you an idea of our method, we will review it briefly. We use a Vandercook 219 proof press with a so-called graduated impression makeready. Luey's (*2*) step wedge printability test is very similar. The press is equipped with a five-section plate, each of which is divided into a solid and four 50% tone screen blocks. The four screen blocks represent 50, 65, 85, and 100-line halftone screens, respectively. Each section of the plate is overpacked to a different impression on the cylinder, so that there is a 5 point (0.005 in.) total variation of printing impression on each sample printed. The halftone areas in each section receive 0.003 in. less impression than the corresponding solid area. A heavy bodied testing, nondrying, black ink is applied to the roller system and plate so that a uniform ink film thickness of 300 microin. is applied to the paperboard sample under test. The sample is printed manually at 180 f.p.m. and fresh ink is added after each two impressions so that the ink film thickness remains essentially constant. The evaluation consists of viewing the sample under ordinary lighting conditions, and determining at what impression value solid ink coverage and continuous halftone coverage are obtained. A two-digit expression, e.g., 8/6, indicates that a particular sample required 0.008 in. printing impression to give a continuous solid print, and 0.006 in. printing impression to yield a continuous tone print. We have found that most boards used to print combination solid and halftone copy should print at 10/7 or less, or they are not suitable for faithful reproduction.

USE OF RESULTS

Probably the biggest single saving attributable to routine printing smoothness evaluation is less press down time. Since our printing smoothness evaluation is done routinely at the end of the paper machine, all board which has greater than a 10/7 rating is rejected and held out for separate processing. This action is a distinct benefit to the printer who no longer needs to shut down his press when he runs into poor printing smoothness board to decide whether or not the stock can be converted by ink and press manipulations, and whether or not the finished quality is acceptable. Moreover, the printer no longer compromises the printing quality on the remainder of a long run should he add more ink and/or impression upon encountering a poor load of stock in the middle of the run. The printing smoothness test thus allows us to separate the marginal printing board immediately, and permits the running of stock at maximum production rates which will require a minimum of press manipulation to get the desired quality. The marginal printing stock is printed after the acceptable board with the appropriate press adjustments so that press down time is held to an absolute minimum with little compromise of the over-all run quality. The biggest saving of printing smoothness evaluation, therefore, is more printing production or less down time. We know that improved printing smoothness has brought about reduced ink film thicknesses and better ink mileage. While we cannot place a dollar value on this saving, we can see the manifestation of this fact in improved trap, cleaner, sharper, stand-up and reverse type, less offset and carton roughness and improved ink lay. We have been able to strengthen inks 10 to 15% in color value, and have been able to get satisfactory coverage with higher tack and body inks. Although higher tack inks normally produce the above benefits, the wetting characteristics normally are not so good as lower tack inks. Smooth board is necessary to transfer thin, tacky films at high printing speeds, and we feel that the associated sharper printing results are a direct result of our routine printing smoothness program.

Another quality feature of the improved printing smoothness is the minimum amount of make-ready adjustments that need to be made in running a given job. Our multicolor printing equipment with a single common impression cylinder does not lend itself to individual color makeready, and we have depended in the past on the compressible nature of the board to compensate for caliper and makeready variation to achieve the desired printed result. Where we used to underlay plates for a given color to produce enough impression for solid ink coverage, we find that this has been reduced to a minimum. We feel this is not due to added compressibility but merely a more level printing surface.

We have been able to reduce our printing quality variation considerably on long runs. As you know, we tend to have long production runs on relatively heavy caliper board, and there is appreciable margin for variation in color, image sharpness, and worn out type and halftones. Improved printing smoothness reduces these variations because we are no longer making ink fountain and impression changes from load to load, and we have not had the number of customer complaints due to these causes as previously. As you well know today's customer is more critical than ever of his carton, because he has intended the folding carton to be a point-of-purchase salesman for his product. Reduction in complaints plus more repeat orders are benefits on which you can not place a dollar value, but the savings and profits are nonetheless tangible.

We do not wish to construe the fact that this program has savings only for the printer, since the producer, in this case the mill, accrues benefits from the routine printing smoothness program also. Whenever marginal printing smoothness board is being made, the paper machine crew is the first to be notified. Corrective action is most beneficial when directed at the source of variation, rather than solely on the printing conversion where variation is after-the-fact.

The time to make a corrective change on the paperboard machine normally involves from 1 to 3 tons of finished board, and hence corrective action on the printing smoothness of a given lot of board affects a number of loads or rolls of stock depending on the trim. Since the mill is anxious to have all board meet specifications within limits, the smaller the amount of marginal stock made and the sooner corrective action is taken, the smaller the tonnage rejected for reprocessing. We are sure you are all aware of the economy of getting maximum acceptable productivity per hour of machine time, and this test is an aid to tell you whether or not the board is printable or acceptable to the converter. There is no question that this program in our mills has reduced customer complaints and credits for poor quality board, and this is a very real savings in continuing profits through repeat orders and satisfied customers.

We can all see better quality demands and highly competitive costs placing increased emphasis on low-waste conversion at maximum production rates. We believe that a tool such as printing smoothness evaluation can help you do a better job of getting more dollars out of every manufactured and converted ton of board.

LITERATURE CITED

1. Eckhart, C. G., and Lewis, R. L., *Fibre Containers* 42, No. 5: 89–92, (May 1957).
2. Luey, A. T., "Smoothness Measurements with Ink Films," *Tappi* 42, No. 3: 185–191, (March 1959).

Presented at the meeting of the Kalamazoo Valley Section of TAPPI held in Galesburg, Mich., March 19, 1959.

Question: The question, if I interpret you right, you ask whether Mr. Luey's conclusion was whether compressibility was really important to printability.

A. T. Luey: The actual compression of the sheet itself during the printing process is of great importance. However the difference in compressibility that you can obtain between one sheet and another, that is of boxboard at any rate, is of very, very minor importance.

Question: We have heard that supercalendering does not improve printability but I gather from Mr. Luey's paper that supercalendering by smoothing out the hills and valleys might be the best attempt to get a good ink lay.

Mr. Luey: I want to state that considering these remarks with caution as they relate to paper and as they relate to paperboard. As far as the original smoothness of paperboard is concerned in its ultimate printing, the smoother the sheet to begin with the better off you are and by a large margin. Consider that first graph that I gave you, Fig. 1: If you have an ex-

tremely smooth, level sheet, absolutely free of felt marks, wire marks, or anything else, that graph will be essentially flat. In other words, at 0.003 impression you will only need maybe 300 microin. of ink to print it and get a solid film and by the time you get out to 0.012 impression, maybe you've dropped off to 250. There is hardly any change. Of course this is ideal from the standpoint of halftone printing where you've got your halftone plates recessed, compared to your solids because you're not getting as much impression on them. Then you have a real nice smooth sheet for your halftone work with lower impression. The original smoothness appears to be very important and this seems to be substantiated by the work of Ragan and the comments that were made this afternoon by Ray Janes.

Question: We would like to know whether Joe Steinbruner has any films on splitting of ink from a roller to paper rather than from roller to roller as we saw here this afternoon.

MR. STEINBRUNER: Yes, we have. We do have a number of very good shots of various things. We have taken a camera and panned from an off-set printing plate back through the roller train and have assembled a group of blow-ups showing the reverse image of the transfers back to roller train, for instance, from the time where there was transfer from blanket to paper or from plate to blanket and form rollers and so forth back. We have also taken a number of shots of coating applications, primarily in coating metal. Our finishing division happens to be in that particular phase and peculiarly you get the same kind of "necking" or filament-forming of a roller coming off of a piece of metal as you do from two rollers in contact. We have a number of old motion pictures and stills of these various things.

Question: Is there any significant difference from metal to the roller in paper—say from coated paper to a roller or from uncoated paper to a roller?

MR. STEINBRUNER: I am unaware of any shots that were taken from a roller to paper.

Question: Then let's say from a plate to paper.

MR. STEINBRUNER: From blanket to paper we have the same general things going on, no matter how you apply a pseudoplastic ink, paint, anything of that type to a different surface. You have the same mechanics, it is a function of viscosity of the material, the angle of exit, speed, and things of that type. So that you have the same general set of circumstances. We have taken shots of a gravure cylinder coming off the paper. Same thing. You always have this filament-forming, the low pressure area, and the eventual attempt of the ink to smooth out and so forth. So the method or the material involved in this application doesn't seem to affect the end result or the picture that you get of the actual transfer.

Question: What do you postulate is the cause of the ribbing and too, what is the effect of ink film thickness on ribbing?

DR. SEARS: It is interesting that one of the first references in literature of this ribbing goes back to the days of hot-tin dipping and tin plating. They saw it when they hot-dipped tin through mill rolls to level it out. And you can demonstrate this to yourself on a small scale by making a suspension of starch in water (you don't even have to cook it very much) and lay it out on the kitchen table or enameled porcelain top table and use your wife's rolling pin to roll it out and you can show the effect of the spacing of the ridges depends on pressure, depends on the viscosity: The more starch you have in it (the thicker it is), the bigger the ridges, the thicker the film, the wider apart the ridges. You can reproduce all these things on a slow scale as well as on this high-speed scale; the ridges are bigger and further apart. In coating nips, coating paper or board, notice the same thing. It occurs in water, it occurs in any liquid splitting except that with a high surface tension-low viscosity liquid, it disappears so fast you don't ordinarily see it. When you are playing with a coating color or printing ink, viscosity is enough that they last long enough to see, even at low speeds. You ask one of the reasons for some of the mottling in solid prints in some cases. With these turkey-tracking, crawling of inks, turkey tracking of coating color and so on, we can show it on a bigger scale by playing with it on the kitchen table or its equivalent with any high viscosity material.

Question: What proportions of ink transfer in the offset process from blanket to a paper?

MR. LUEY: There have been many reports on this by Lehigh covering a wide range of ink film thicknesses. At very, very light ink film thicknesses, the percentage of transfer is relatively small. As you increase film thickness, transfer builds up until it reaches approximately 50%, sometimes it goes over a little bit, but about at this level where you are getting a transfer of about 50% of the ink film, approximately, you are in the range of normal printing. The ink film thickness where you would normally be. And this, in letterpress printing, is not too great a spread. I would say for good printing purposes normally the ink film on the plate should be between 250 to approaching 300 millionths of an inch. As you would keep on increasing your ink film on the plate the per cent transfer drops off again. They have found that this will vary with certain types of boards. I believe just exactly where this peak occurs with ink film thickness depends on the smoothness of the board.

MR. STEINBRUNER: Essentially the same thing happens on an offset press. If you are operating within normal film thickness ranges you will find that the ink film will split just about half and half. Visualize the fact that you are trying to print from the top of a pail of ink, you couldn't begin to transfer 50% so you've got to keep your thinking in normal printing ink applications. When you start talking about lithographic applications you have exactly the same relationship which you have on letter press. Half of the ink which you meet with unprinted or uninked surface will transfer.

So basically, as nearly as we can measure, rollers in motion or static, you will find that film thicknesses beyond the exit nip are very, very close to equal. And that pretty much holds true with any type of film splitting or film separation.

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E470-59. Chemist (BS) and Chemical Engineer (B.ChE.), age 39. Five years heavy chemical plant supervision. Ten years paper converting. Experienced in plant management, staff level, and technical liaison at all levels. Extensive R & D background in process and machine development, intimate knowledge of coating materials and methods. Desires position in plant management, or as Manager of R & D.

E471-59. Research group leader, Ph.D. (1946). Twelve years' experience in leading research and development teams. One year's experience in heading quality control department. Have initiated important developments in pulping, bleaching, and paper research. Familiar with the production of a wide variety of pulps and papers. Desires responsible position in research and development production or a chemical company serving the paper industry. Complete résumé supplied upon request.

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WEST VIRGINIA PULP AND PAPER COMPANY

COVINGTON, VIRGINIA

(P870-59)

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Graduate mechanical engineer preferred for sales of paper converting machinery. If inexperienced, we will train. Excellent opportunity. Generous profit sharing bonus plan and stock purchase plan. Applications will be held in strictest confidence. Send résumé to:

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Frank W. Egan & Company
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Chemical or Chemical Engineer, with 3–5 years' experience required by resin manufacturer to evaluate resins and assist in design of new products for applications in paper and paperboard. Knowledge of paper coatings and general resin applications to pulp and paper desirable.

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Personnel Department

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(P875-59)

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Research Director

West Virginia Pulp and Paper Co.

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Paper Technology, Chemistry or Chemical Engineering background is preferred.

Two or three years experience in Process Engineering or mill technical service work is necessary for this position.

These positions are located in Central Wisconsin.

Please give full details and resume in your first letter so that interviews can be arranged. Send to P881-59, Tappi, 155 East 44th St., New York 17, N. Y.

EIGHTH CORRUGATED CONTAINERS CONFERENCE

Technical Association of the Pulp and Paper Industry

CINCINNATI, OHIO, NOV. 4–6, 1958

Indirect Labor

ROBERT C. ETNIRE

This paper presents the various causes of excessive indirect labor costs in the corrugated box shop. Management philosophies and methods, and employee attitudes and communications are analyzed as the factors to be considered in correcting an excessive indirect labor situation. Programs such as budgets, training, communications, and other management tools are offered as a means to control indirect labor costs.

The cost of indirect labor is today, more than ever before, a major factor—almost, I might say, the deciding factor, in the success or failure of a corrugated box shop operation. The cost of this labor is of prime concern to all managers and particularly to those of us associated with a "job shop" type of operation.

Our industry is possessed of three characteristics that make the indirect labor problem quite acute. First, it is one of the most competitive industries that our free enterprise economy has ever known. Secondly, because of this intense competition our margin of profit is somewhat lower than a great many other businesses, especially the "hard goods" industry. In other words we cannot increase the price of our product because of an increase in costs. Thirdly, our industrial process is such that a great deal of material handling labor is required.

Most of us are guilty of operating our box shops with too much indirect labor. For years we have been concentrating our attention on the reduction of machine crew sizes, increasing machine speeds, purchasing new equipment; all for one ultimate purpose—to reduce direct labor costs. We have spent millions of man hours studying ways and means of reducing waste and starch costs. We have discussed these problems with each other. We have had them on the agenda of conference after conference. But this is the first time, to my knowledge, that we have discussed the subject of indirect labor at a conference of any kind.

To discuss the subject of indirect labor intelligently we must first be able to identify it. We are not all accountants and sometimes we are apt to be confused by the various interpretations of accounting practices and procedures. Most accountants however agree that indirect labor is that labor which is required, yet does not add to, change, improve, or otherwise increase the sales value of the product. Labor such as stockers, truckers, service men, maintenance, janitors, baler operator, and shipping are easily identified as indirect. There are always exceptions to this, of course, depending upon the nature of your operation.

Now that we have established the general identity of indirect labor, let us take a look at some of the characteristics of this labor to find out more about it.

Indirect labor is a sensitive area of labor relations, and as such, lends itself to the "bargaining table" more so than direct labor. The unions take a more personal and protective stand where this type of work is concerned. We are at fault for allowing this to happen because most of us have not spent enough time with our indirect problem. Facts and figures are easily found for our direct labor problem. For indirect we usually offer only opinions and weak arguments. There is no substitute for facts, expertly uncovered and skillfully presented.

The work activity factor always presents a problem as it is usually quite difficult to schedule this type of job so that it offers no waiting time or other idle elements. It is also more difficult to measure indirect labor by time study or other means due to the many variables usually associated with this type of work.

Now that we have analyzed this labor academically lets take a practical look at the various causes of excessive indirect labor costs.

The high cost of indirect labor is the price we must pay for negligence as managers. Some companies in our industry are guilty of operating without monthly cost reports. They have no yardsticks for measuring productivity. Operating budgets are considered an invention of the devil himself. These managements attempt the impossible—to operate a modern industry with antiquated (country store) methods. Without modern management controls, and an enlightened and progressive management to administer them, costs can easily get out of line.

Inadequate supervision is another cause of excessive indirect labor costs. I refer here to quantity as well as quality of supervision. If you are guilty of a situation whereby your salaried foremen have too many people under their supervision, you will probably have too much indirect labor. A foreman cannot efficiently supervise over 16 to 18 people under normal operating conditions. If he does he cannot give the necessary attention to the details of his job and subsequently loses the all important control that is required for a good operation. A foreman in this category will add an extra man to his operation chiefly because he doesn't have time to analyze the situation and this seems the easiest and quickest solution. He might make the same decision, even if he only supervises six people, unless he understands costs. If he has not been trained in cost control he will be prone to make costly decisions. I think that most of us will find that our indirect labor costs are high because of that extra man we put on a certain operation a few years back, because of some emergency, and for some unexplainable reason we have failed to take him off the job after the emergency is over. Sometimes we can't remember what the occasion was that required this man's services! Has this ever happened in your plant?

Inefficient methods and poor layout, combined, are the third major cause for high indirect labor costs. Again we have been guilty of not improving our position due to negligence. Sure, indirect labor is a more difficult problem to cope with than direct labor. It requires more time, more understanding, and improved techniques. Antiquated material handling equipment however is inexcusable. The payout is often faster for this equipment than it is for box

Robert C. Etnire, Director of Production, River Raisin Paper Co., Monroe, Mich.

making equipment. Whether you have a conveyorized plant or a skid or pallet plant you can still improve your methods and layout. You can no more relax your attention to material handling and layout improvements than you can ignore the improvements in printing and finishing equipment or any other operation. You, as a manager, must stress the importance of this to your staff and your supervision.

If your company is beset with one of these weaknesses then your indirect labor is bound to be excessive. To correct this situation is no easy task—it cannot be done overnight. Careful planning is required. The very first thing to do, of course, is to identify your indirect labor properly and make sure your accountants are properly distributing this cost. After this has been done your costs should then be analyzed and compared with other plants within your company and with competitive plants wherever possible. One thing to watch for in this comparison—be sure that you are speaking the same "indirect labor language." After you have made these comparisons you can then determine just how far out of line your costs really are. When you have made the decision that your costs are too high and you must take corrective action, call upon your engineering staff or engage the services of a consultant to study the problem for you. I should mention one important factor at this time—your entire organization—foremen, union committee, and all hourly employees must share this problem with you. Lay the facts completely on the table—withhold nothing. You must do a good communication job at this point or the entire program will be undermined before it is started. Every individual in your organization must know the complete story. They have a right to know when something is wrong with your plant operation. If your indirect labor costs are untenable tell them so, detail after detail.

After the engineers have studied the problem, you, as the manager, should meet with them and advise them in the presentation of their report to top management. After the report is studied and the recommendations approved by all concerned, then your work really begins. Your program and the communications thereof will have to be expertly planned and skillfully carried out. The timing is very important and has to be handled more expertly than the biggest television extravaganza. One word of caution, however. Do not try to correct this problem in a "piece meal" manner. It is much better to have one major crisis in your plant than to have a series of minor crises. I'm sure our labor relation experts will agree with that philosophy. In other words, let's correct the high cost of indirect labor plantwide, not one operation at a time. Explain to your people where your costs are out of line and why. Prepare charts, graphs, and cost figures comparing your operation with other plants. Shut down your machines department by department and conduct meetings. Your union committee should naturally play an important part in the scheme of things. They will cooperate if you present the facts clearly to them, keep them posted daily, and above all ask them to help you lick this problem. Unions are not completely negative in their approach to industrial problems. Like any of us they want recognition for their responsibilities. If you recognize this fact your program will succeed beyond your highest hopes.

Now let's talk about the control of indirect labor costs as applied to a well organized and efficiently operated plant. First, management must be constantly alert, ever progressive, and well trained in the latest management techniques. Secondly, administrative controls such as monthly unit costs, reports, man hour productivity reports and operating budgets, are of prime importance in the control of indirect labor costs. One note of warning regarding the budget is that it should be approved by the operating head before it is put into effect. The budget should be administered by the general manager's staff for a small operation and by the controller's office in a large corporation.

To properly control indirect labor costs, the manager must have certain yard sticks in addition to budgets and other cost reports. After a careful analysis of our own plants and of various competitors, I have developed the following yard sticks to enable me to quickly analyze a plant's indirect labor situation.

1. The ratio of indirect labor to direct labor should be no greater than 0.5 to 1, or conversely, the direct labor should be 2 to 1 over indirect labor.

2. The burden rate (including indirect labor and all other overhead) should run between 150 to 200% depending on your position relative to fixed charges. If yours is a new building furnished with new equipment your burden rate should be no more than 200%. If yours is a well established plant fully depreciated in part, then your burden should be approximately 150%.

A second factor to be considered in the control of indirect labor cost is the training of your foremen and other management personnel. We, as managers, are woefully weak in this area. We could learn a lot from our unions in regards to training. If you have a small operation and do not have the time or the talent to establish your own program, then the universities are your next best source. Today, our schools offer many courses in industrial management and many are taught by men who have had a varied experience in industry. Your management people have to be trained—make no mistake about that. The international representatives of the unions are sent back to school almost every year to gain more knowledge and improve their techniques. They also learn all they can about "our" jobs. We, as management, must keep pace with this philosophy of training or be left behind.

The three most important subjects of training that should be offered to your foremen are as follows: (1) practical communications, (2) human relations, and (3) cost accounting.

If you expect your foremen to be responsible for costs, then it is mandatory that he understand the procedures by which his costs are accumulated. If you expect him to keep pace with his union counterpart, then you must give him the opportunity to improve his knowledge and his techniques.

A third management control is a policy of continuous improvements to methods and layout. No business can stand still. You either move forward or lose position. To properly control your indirect labor costs, and to keep moving forward in your industry, you must set up a program of modernization and improvement. Each year a certain amount of money must be set aside for improving your material handling and other indirect operations. Remember this—your indirect labor cost is 50% of your direct labor cost if you have a good operation, and may run as high as 75% or more if your operation is not efficient. Because of this you just cannot afford to treat your indirect labor problem lightly.

These are all good management controls, but to insure their success you must develop your communication skills. Communications are much like our weight. We all talk about it but few of us indeed do anything about it. We tend to oversimplify our communications when we should carefully plan this management technique to the very highest degree. It takes a great deal of skill and hard work to communicate effectively. Don't use this management technique only when you're in trouble. Plan your program so that good communications will become a daily habit. Tell the people working for you as much as you possibly can about their company and their jobs. If you do this your program of cost control will be successful.

Despite some union opposition, and the normal resistance to change inherent in most people, you can still make progress in cost reduction if you persevere, get all the facts, train your management people and communicate.

Presented at the Eighth Corrugated Containers Conference of the Technical Association of the Pulp and Paper Industry, Cincinnati, Ohio, Nov. 4–6, 1958.

Various Methods of Materials Handling in the Corrugated Box Industry

RAYMOND S. OWEN

Although the common tools for handling materials from the corrugator through shipping are well known, and although the objective is the same everywhere (handling sheets of corrugated board) the selection of the tools for handling materials varies considerably. We can divide ourselves into two groups for identification of the problem —old plants and new plants. If, in an old plant, we are considering revising materials handling procedures we have all the frustrating limitations of posts, ceiling heights, multifloors, etc., to contend with. If, in a new plant, we have one flat surface to cover with machines and to arrange for the best flow of materials, we have the many alternatives presented by product mix, and company manufacturing policies to be considered. There are four well-known basic materials handling methods used in box plants and in our analysis of these methods, we will find ourselves facing a multidimensional problem.

It is said that 49% of manufacturing capacity in the paper and pulp industry dates back to before 1945 or about 14 years*; we probably do not have that situation in corrugated because of the considerable new capacity and the extensive modernization in equipment since the war, so I will venture to say that 35 to 40% of our machinery is over 14 years old. Making a rough comparison of the performance of the typical old corrugator to a new one, we will find among the older machines a direct labor cost of between $0.20 to $0.35 per thousand square feet, and among the new ones, a cost of between $0.12 to $0.19 per thousand square feet, a drop of between 40 and 50%. These figures tell why there is strong pressure on corrugated manufacturers to improve the old or to have more modern corrugating equipment. As a manufacturer responds to this pressure to have machines of greater productivity, he increases the volume of work going through his plant.

The old full automatic slat feed taper might turn out as many pieces per hour as a current folder taper, but you could put a couple of folder tapers in the same space required for the automatic slat feed with its folding tables.

A new printer slotter is going to put a demand on the materials handling facilities but nothing compared to the increased volume of production introduced by a new high-speed folder gluer. All these pieces of more modern equipment demand more efficient materials handling.

It is a very rare instance, as you all well know, when a box plant will have surplus space; therefore, we may be faced with the situation of increased volume going through the plant with fixed space limitations. It is for this and other reasons that materials handling know-how is particularly vital to progress in the corrugated box industry.

MATERIALS HANDLING EQUIPMENT IS KEEPING PACE

Over the last 15 years, we have had many improvements in our materials handling equipment. It was only as far back as the late thirties that men handling rolls would attack the roll that was in a vertical position with a rounded stick which they would insert in the core, pull the roll toward them on to a two-wheel dolly, and then move the roll from one location to another by pushing the dolly. That was the old-fashioned version of the Bartel device!

Roller conveyors have been used for a considerable period of time and their usefulness, because of better skill in utilizing this agency, has increased materially in the last 10 years. The Pul-Pac device which is gaining increasing popularity among box plants was introduced by the Clark Equipment Co. just 10 years ago. The sheet turnover device of Greene Line Manufacturing Co. was introduced some 5 years ago. Various attachments, such as the revolving clamp, carton inverter, and the Bartel device, are more recent improvements.

We have sort of a neck-and-neck race between those who manufacture production equipment and those who manufacture materials handling equipment. The challenge to materials handling know-how is very real.

THE VARIOUS METHODS USED TO HANDLE THE WORK IN PROCESS

How are we meeting this challenge and what are the various methods we use to handle the work in process, and how can one evaluate each one?

It would be somewhat of an oversimplification to say that there are *X* number of materials handling methods used in our industry. However, for the purpose of proceeding with our discussion, I am asking you to go along with me when I say there are six basic methods used: (1) hand truck, (2) skid, (3) lift truck, (4) Pul-Pac, (5) roller conveyor, and (6) Towveyor.

I do not attempt to evaluate these procedures one against the other—each one has its merits. The situation, materials handling in box plants, is far too complicated for anyone to take the position that any one of these systems is the right or the wrong one. A correct position that one might take would be that his method is the correct one for his plant.

If we would evaluate these several materials handling methods, we must analyze or break down what is done. There are operations and moves.

A regular slotted carton sheet moves from corrugator to presses to joining and out through shipping. Between each of these operations, there are storage areas. We make this analysis by stating these things as a flow process chart. For example:

1. Move sheets from corrugator to temporary storage area ahead of printer slotters.
2. Locate and move sheets from temporary storage area ahead of printer and place in position for printer slotter feeder.
3. Move blanks from printer slotter operation to temporary storage area ahead of joining.
4. Locate and move blanks from temporary storage area ahead of joining and place in position for joining machine feeder.
5. Move boxes from joining operation to temporary storage area ahead of shipping.
6. Locate and move boxes from temporary storage at shipping to cars or trucks for shipment.

EQUIPMENT

What do we have to work with? What equipment do we use? Each of you will have some of these items with which you move the product through the shop. For handling sheets:

Lift trucks[a]	*Attachments*	*Misc.*
Low lift	Forks	Roller conveyor platform trucks
High lift	Plate	Hand platform trucks
	Pul-Pac	Roller conveyor
	Carton inverter	Towveyor
		Hand trucks
		Skids
		Pallets
		Rack bodies
		Two-wheel hand trucks
		Walkie trucks

[a] Gas or electric powered.

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* *Business Week*, Sept. 27, 1958.

OBJECTIVES OF MATERIALS HANDLING

In general terms, our problem is to move sheets from one place to another. But that in itself is not enough—an efficient flow of work in process must be accomplished. I'll try to put our objective into words:

1. To make the material (namely the product, the sheets, etc.) available to direct labor, in position to be used without causing delays and at lowest true cost; and

2. To take the sheets or the material away from direct labor without causing delays, and at the lowest possible true cost.

For example, we take the sheets from the corrugator to a temporary storage area and some hours later to the printer where they are placed in a position for the feeder to pick up the sheets with minimum difficulty. In other words, make it available to direct labor in the best location.

As the work is completed at the printer and stacked by the take-away man that stack which he has made must be removed for him or by him, without loss of productive time. In other words, take the finished stack away from the direct labor operation immediately.

Insofar as we do this job properly, the objective is attained and we have the uniform flow of production which is necessary, and the lowest possible true cost of materials handling.

Why do I say "lowest possible *true* cost"? Because we must not lose sight of certain cost-making situations—I refer to waste, safety, and quality.

It is only by attaining low costs that any service function is justified, and we will make a mistake if we are not concerned by these related costs. If we claim a saving of indirect labor in the movement of materials but increase the cost of waste, we may not have gained a true saving.

Any procedure for handling materials that creates a safety hazard has not gained a true saving. For example, a materials handling arrangement which does not provide for reasonably quick identification of loads, and for this reason men from time to time walk on the top of loads to locate one, is not obtaining the objective nor is it attaining a low true cost. By the same reasoning, any materials handling procedure which encourages or permits a truck driver to manipulate his vehicle carelessly and thereby cause an injury, adds to the true cost.

I would like to say parenthetically that this careless truck driving is a sore point with me. When I was with Fort Wayne in the early forties, we had a rather poor safety record which all hands were working diligently to change. We were getting results—in fact the Chicago plant had a 364-day no lost-time accident record, and the possibility of running a full year without anyone being injured and losing wages was everyone's hope, when a careless truck driver ran over an employee's foot spoiling our 1-year record we had so hoped for, but more important, did injury to a fellow worker, causing him to lose time and wages.

The actual cost, i.e., the initial cost of the equipment, the maintenance of equipment, the evaluation of the number of man hours of indirect labor involved, and the saving in direct labor man hours are matters of arithmetic. Along with the arithmetic, we must be aware of those related situations; the effect on waste, the effect on quality, and the effect on safety.

To repeat: our objective is not only to move the work in process but to move it efficiently thereby accomplishing the lowest true cost—we will measure this in savings in indirect labor, increased productivity by direct labor and a stabilized situation in waste, safety, and quality.

Throughout this analysis and planning for better materials handling, we are aware that people are going to push the trucks, guide the lift trucks, and perform the productive operations.

I was in a plant recently that I hadn't visited for about 5 years and we were talking about materials handling. The manager told me they had just the finest system in the world. They never had any of the embarrassing delays which so many people experience; the work was always up to the machine when the man wanted it, always in the correct position and always taken away promptly as the operation was completed. As we walked around the plant, I noticed that the two truckers who were in the key points were the same two who were there 5 years ago. This manager had a favorable "people" situation, not necessarily a favorable "system" situation.

Another point on the matter of people. It is encouraging to note that manufacturers of materials handling equipment are distributing pamphlets of instruction for in-plant truck drivers which should be of great value to the training of drivers. The Clark Equipment people have films for the purpose of training truck drivers. It is their position that it is as important to train the truck drivers on Pul-Pac installations as it is to physically maintain the equipment.

ANALYSIS OF ONE METHOD

What method should we use? It is a well known step in problem solving that once the problem has been identified one must *get the facts*. This means observation, collecting data, and analysis.

The items in the flow process chart noted above show one way to get our problem in focus. Let's take another step and draw a picture in our mind's eye of what goes on at each item, using one of the six basic methods. No one on this panel is going to talk about Pul-Pac, so I will use that method as my example.

We will examine each move somewhat minutely, just what is done and how? (the work simplification key words "Is this necessary" come later).

1. Move sheets from corrugator to temporary storage area for printer slotters.

Pul-Pac truck driver draws the pile of sheets made by the corrugator take-off men onto the Pul-Pac plate and drives to temporary storage location; drops pile or stack in a known location.

2. Locate and move sheets from temporary storage and place in proper position for printer slotter feeder.

Pul-Pac truck driver finds the stack in temporary storage, draws onto Pul-Pac plate and drives to proper machine; drops onto roller conveyor leading to the machine.

3. Move sheets from machine to temporary storage area ahead of joining.

Pul-Pac truck driver draws the pile of sheets off the exit conveyor at the press onto the Pul-Pac plate and drives to location of temporary storage ahead of joining; drops stack in a known location.

4. Locate and move blanks from temporary storage area and place in position for joining machine feeder.

Pul-Pac driver locates the stack and delivers to automatic turnover device for reversing the sheets. Sheets are then moved on roller conveyor to the sections of conveyor ahead of the particular joining machine.

5. Move boxes from joining and locate in temporary storage ahead of shipping.

Pul-Pac driver draws stack onto Pul-Pac plate and moves to temporary storage in the shipping area and either places on the floor for subsequent handling by Pul-Pac driver or places on a pallet for lift truck handling, or places on a truck for hand movement, or places on roller conveyor arrangement for banding.

Such a course might be followed by sheets when the plant has a Pul-Pac materials handling method.

COMPARATIVE ANALYSIS OF ALTERNATIVE METHODS AND FINAL DECISION

Having in mind how the Pul-Pac method would operate, it would be advisable to examine another method (for example, roller conveyor). This is readily done by visualizing each of the flow process steps when using roller conveyor (or other equipment).

Decision on what method (or combination) comes only after more minute examination of each step. This is accomplished by applying the analysis of work simplification, by making out flow charts or travel charts and by making extensive use of time study, delay study, and work sampling data. Consideration must be given to the usefulness of each item of equipment available in relation to the plant's manufacturing procedures, the building characteristics, the estimated volume in total and the various items in the product mix. This is a task which requires the full skill of a well-trained industrial engineer. A very useful check list of standard questions is to be found in Ronald Press Co.'s "Materials Handling Handbook," Section 2, page 3. The data thus established form the basis for determining costs and selecting the methods.

Actually the selection of materials handling equipment for any particular product is guided by an old fundamental rule of packaging that is expressed so adequately in the phrase "the egg crate is as it is because the egg is as it is."

PLANT AREA REQUIREMENTS

During the preparation of this paper, I asked some box makers to give me data from which I could calculate an index figure to represent the number of square feet of manufacturing area in the plant per 1000 sq. ft. produced per month per shift. I was given the figures representing the square feet of the manufacturing area, excluding roll stock storage, the average monthly production, and the number of shifts at the corrugator and at the other machines. I received some 40 replies. The square feet of plant area per MSF per month per shift ranged as follows:

	Square feet of plant area per MSF per month per shift
1. Pul-Pac	3.5 to 10.8
2. Trucks	3.1 to 12.3
3. Roller conveyor	2.8 to 13.1

The arithmetic averages of the square feet of plant area per MSF per month per shift as determined from the replies are:

	Square feet of plant area
1. Pul-Pac	6.8
2. Trucks	7.5
3. Roller conveyor	8.4

You are familiar with the real contributions made on this subject by Ron Wilmer of American Box Board, and will be interested in answers Ron gave me when I asked how much larger his storage areas would have been if he had used roller conveyor in the storage section rather than Pul-Pac. Ron isn't one for giving off-the-cuff, careless answers, and really ran my 'phone bill up with his "if such were the condition," or "if so and so were the manufacturing policy," etc., etc. I think, however, Ron would permit me to say that in view of the fact that he stores two or three high, he is utilizing "air rights," i.e., the cubical content of his plant, and getting a 60% storage gain on the floor space area. He would have me add the qualification that this is possible in his case because he has an 18-ft. ceiling and because of their particular product mix. If, for example, another company had more small cartons than American Box Board, their percentage might be less since you cannot tier very small cartons three stacks high. He would also have me add that 60-in. tiers are standard for three high piling. Aisles are 10 to 14 ft. wide—they were made so to accommodate the large sheets which they anticipated in their production. Aisles this wide might not be necessary in another situation.

NEW METHODS

There are many items currently used in materials handling which we have not adopted in the box business, as yet. Among materials handling people "air rights" is a key point. My associate company was instrumental in reducing the number of workers handling semifinished and finished materials at the new Evinrude assembly plant in Milwaukee by 26% by mechanization of material handling and increased the storage capacity 50% by the use of air rights. In the assembly operations, productivity was increased 50% by mechanization of the assemblies. Their plant is now 95% mechanized which might be a goal for us to shoot for.

We utilize air rights with the Pul-Pac method and we utilize air rights by the trim removal method common among box plants. Could we utilize air rights by overhead transporting sheets across to the parts department from the corrugator? Some plants have an underground disposal for waste—could we utilize air rights to dispose of waste that cannot be taken through the trim removal method? Would a humidity and temperature controlled loft be satisfactory for tape storage and for printing dies? In packaging operations, it is common to move packages on live conveyors, distribute them to packing stations by electronically-controlled switches. Is some such arrangement practical in our shipping rooms?

CONCLUSION

I have mentioned that materials handling must be set up with people in mind. I recalled the company that is very proud of the system they use and I noted that the two key people, the truckers, had been on the same job for 5 years. Motivation is necessary and training is necessary because people can make or break a materials handling system.

Those of us who are, in one way or another, responsible for accepting the challenge that modern and more productive machinery has given to materials handling are aware of the complexities of our problem. We feel that in truth it is a multidimensional problem and it is one in which the application of care and skill has great rewards both in keeping up with the challenge from more productive equipment and in the very great satisfaction of a job well done.

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Towveyors for Corrugated Box Plants

GEORGE BERLIANT

Our latest plant expansion, increasing plant size to nearly 300,000 sq. ft., necessitated finding a new answer to efficient materials handling. Various methods were studied with the result being that a towveyor chain was selected. The chain conveyor was sunk into the floor and all machinery, except the corrugators, moved around the periphery of the plant. Practically all face the towveyor chain. The chain rides in a channel or groove in the floor with a hook, triangle shaped, projecting 2 in. above the floor level. It is 2400 ft. long and is driven by two 10-hp. motors with hooks located 30 ft. apart, with chain speed of 30 f.p.m. A large advantage to us has been savings. We estimate that the recovery of our investment was made in less than one year based on three shift operation. A further advantage has been fluid storage. As department backlog became too great, we found the system simply absorbed part of a neighboring area load. There are some disadvantages such as the hook engaging mechanism is not entirely foolproof and truck maintenance is more involved than with our old system.

THE mortar between the bricks of our latest plant addition was just about dry, so it was time to begin planning for our next expansion.

GEORGE BERLIANT, Stone Container Corp., Chicago, Ill.

This time we had some rugged problems to overcome. Our plant would cover close to 300,000 sq. ft., which meant that there would be some long hauls with work in process and finished goods. The answer obviously was an efficient materials handling system, and at this point our search began.

We had, a few times in the past, investigated complete floor conveyorizing, and to make sure that no stone was left unturned, did so again; but again came up with the same answer; our type of orders, being as small and diverse as they are, would not be handled efficiently by this means. (I am not implying that this means of materials handling is inefficient; I am sure that it is the best system for certain operations; it just wouldn't work for us—and I want to point out that this same statement can apply to any other method mentioned.)

We looked into regular fork truck handling. Again, there was no appreciable savings, and in addition, quite an investment required in pallets. We also investigated Pul-Pak. Here again our engineering studies indicated that there would be no appreciable manpower savings when compared to the system then in use. Our old system, incidentally, consisted of four-wheel trucks, 3 ft. by 6 ft. in size, with two large fixed wheels in the center and crazy wheels centered fore and aft; and one of our cost problems was our investment in these trucks—about $60,000 worth.

Our search then took us in the direction of chain conveyors, and although, as with anything new and different, there were objections, and even obvious bugs (also some bugs which weren't obvious) in total this looked like our answer. To date we haven't regretted it.

The plan involved moving every single machine in the factory with the exception of the corrugators, and a complete rearrangement of the floor layout with all production machinery more or less aligned around the building periphery, the output end of each machine facing the towveyor chain so that a short push and position over the chain groove was all that was required; this was to be done by the take-off man at each operation. Fortunately, a relatively minor addition to our trucks very nicely converted them for use with this system.

The chain sits in a channel or groove in the floor with only a hook, which naturally is called a "dog" protruding. This dog is a right triangle-shaped protrusion, standing 2 in. above floor level, spring hinged in one direction so that it will depress into the groove if stepped on. The chain is 2400 ft. long, and is driven by two 10-hp. high-slip motors. Actually, one of these motors is more than sufficient to drive the chain. The dogs were originally spaced 15 ft. apart and were a cause of great concern, as we thought that there would be an insufficient number distributed along the chain length. Since operations began, we have removed every other one; they are now 30 ft. apart and the spacing works very well. The chain travels at 30 f.p.m.

The truck is drawn along, simply by having the protruding dog engage a V-shape open back cow catcher fastened to the bottom of the truck. The truck is stationed over the channel, and the next dog along engages it and supplies the motive power. To remove a truck involves merely pushing it forward a foot or two and then turning off.

Installing the chain bed in the new building section was no problem as the concrete was poured to receive it. The old section did present a problem, however, as trenching and installation of the framing, etc., had to be accomplished without stopping operations. Our engineering section deserves a great deal of credit for planning the entire operation, step by step, so that not a single machine was shut down because of the chain installation.

Before the new operation was started up, we held a number of sessions with our supervision and our factory people. Manpower was assigned and trained in advance. We had two dry runs of 1 hr. each. Then the date to start up arrived. Our training paid off, because by 11:00 that morning, you would have imagined that our materials handling system had been in operation for months.

We had been a bit concerned about safety in conjunction with our new system. We made a wearing of safety shoes compulsory on a subsidized basis, and talked up safety a great deal. I am happy to report that we have not had a single accident attributable to the towveyor. Oh, you will see someone occasionally forget himself and trip over a dog. Generally, if this happens, someone is sure to remark "We'll have the maintenance department remove that this weekend." Even if you were to forget yourself entirely, and stand on the track with your back to an approaching truck, at 30 f.p.m. the nudge that you receive is much more than sufficient warning for you to get out of the way. Thirty feet a minute is about one-tenth walking speed.

There are 18 stations around the track where the chain can be shut down for emergency or any other reasons. Shutting down actuates both a red light and a buzzer at the station—a rather raucous buzzer, deliberately made so, so that no one is too interested in leaving the towveyor down for long. For safety, only one station, located in the production control office, can start the line. It is necessary to phone there when the line is ready to operate.

It is difficult to determine what such a system would cost you, as compared to what it cost us. First of all, you all know what has happened to the price of capital goods in the last five years. Also, our installation was a combination of new and old, which distorts the picture somewhat. For what it is worth, our installation ran about $25.00 per foot, all inclusive.

To us, our savings are obvious. As you see the chain in operation, and mentally picture someone behind each truck moving along the chain pushing it, there is very little doubt that we are saving money. Our experience showed a recovery of cost in less than one year, based on a three-shift operation.

This floor layout also gives us another advantage—fluid storage. You might say that the entire plant center is general storage, and as there are only so many trucks to place merchandise on, an overloaded department simply borrows some space from his neighbor.

There are disadvantages too, of course. The hook engaging mechanism, an nonstandard unit, does leave a bit to be desired, as it is not foolproof. Also, maintaining our trucks is more involved now than with our former system; but rest assured that we have found the advantages to far outweigh the disadvantages.

It is a method which, for the plant whose type of business makes this system fit in, cannot be beat in my opinion.

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The Conveyor Method of Material Handling

HARRY STERNFELD

The particular points discussed are the physical advantages in the use of roller conveyors in a converting plant, of small to medium size (3 to 10 million ft. per week), from corrugator to shipping door, against other material handling methods. Use of roller conveyors properly arranged in the operation will result in a direct labor saving in interdepartment handling per thousand square feet, as well as very low indirect labor and overhead charges. The high initial cost when spread over the years coupled with low maintenance, repair and replacement costs, makes a roller conveyor operation comparatively inexpensive.

HARRY STERNFELD, Chief Industrial Engineer, Grand City Container Corp., North Bergen, N. J.

By DICTIONARY definition a conveyor is a device for carrying or moving material. For our discussion at this meeting a conveyor is a roller conveyor with regular or live rollers, mounted in a solid metal frame and standing on or imbedded in the floor.

For a converting plant to be considered as having a conveyor method, over 75% of the internal movement and storage of the sheets must be done on these conveyors. There are many plants operating today with mixed material handling methods and using various moving devices, including roller conveyors. I will not, in this discussion, consider spot usage, as only certain of the advantages, inherent in a complete system can be attained.

Spot use, however, should not be eliminated from your future consideration: that is, if you are planning a building or layout change. Such use, if it were to be well planned and integrated with your existing method for a specific manufacturing operation could possibly realize substantial saving over your present over-all system.

Before we go into the details, I would like to give credit to the Logan Conveyor Co., Louisville, Ky., who have supplied me with information. If, after the talk you have further questions regarding the method, I will be glad to answer them for you. If you have technical design questions, please see their representatives who, I am sure, would be more than happy to answer you on design and selection of equipment.

If you were to prepare and analyze a material flow diagram of your existing operation or your planned operation: that is, if you do not have a conveyor system, the questions that should be uppermost are:

1. "How much rehandling" of the sheet is done without performing a converting operation between the "pick up and lay down?"

2. How much extra moving is being done to keep the necessary production flow?

As converters, the results of such an analysis are very important. All we are selling is conversion of the containerboard into a finished product to customer specification. We are only paid for the labor, material, and machine expense incurred by the operations performing the conversion and for the necessary movement from one manufacturing operation to another. Labor and its corresponding overhead expense, incurred by extra rehandling, additional movements, improper storaging, is an expense, for which we get no return. This additional expense, therefore, reduces our profit margin.

An analysis made at a plant using a wheeled truck system showed a penalty of 25% in direct labor cost at their major operations for moving loaded trucks away from the production work stations, to clear the area for production work. In addition, a good number of so-called floor help was needed to move these loads to and from storage and to succeeding operations, and to keep the loads marshalled for better control. This company at its first opportunity designed and built its new plant around a conveyor system.

Conveyors are not the ultimate and final answer for every box shop—and all other systems N. G. Conveyors, I believe, have their greatest advantage over other methods for handling the product in job-type shops doing from 3 to 15 million ft. per week.

To point up these advantages, I have planned a word and picture tour of a converting operation in this range, an 8 million-ft. shop, operating one shift only. This operation is in the East. It services a great number of smaller customers, and a few volume users with regular boxes and parts, as well as specialties. The average box order is under 2500 cartons per order. This plant is individually owned, therefore, the initial investment in building and equipment had to be kept within practical bounds. The building was designed to the owner's specification around a conveyor layout.

We will now start our tour, as we go along, I will discuss the advantages and disadvantages at the various operations.

The first operation in the series is at the single facer section. Here is a clamp equipped lift truck delivering a roll to the single-face roller conveyor, which is imbedded in the floor. The truck operator positions the roll onto a platform which rolls over the conveyor. No other positioning of the roll is needed.

The shafter now pushes the roll into position behind the roll stand. Moving this 3 to 4 thousand pound roll into position, so easily, by one man could only be accomplished with a roller conveyor.

Many convertors use roller conveyors in their right angle take off. However, after the sheets are removed from this conveyor various other methods are used for movement to the following operations. In this plant, the sheets are placed onto a roller conveyor by the sheet catchers. Before the catcher starts making up a pile of sheets, he places an aluminum plate on the rollers. These aluminum plates or riders are necessary to ride the corrugated sheets when the distance between the rollers is greater than 4 in. This section of conveyor is mounted on wheels with the track on top of the floor, and is also know as a transfer car.

The conveyor when loaded to the proper height, will be pushed to the temporary storage line until additional loads for this order are accumulated. A maximum height of 6 ft. above the conveyor has been established to make it easy for the feeders at the printer slotters to pull the sheets down. This operation, pushing the transfer car to the temporary storage section, bringing the car back to position, putting the plate on, is a very quick one. The catchers when they finish this cycle usually find one to three good lifts of board to pile, which they do quickly to catch up and not jam the knife.

The sheet catcher pushes the load onto the storage conveyor from the transfer car. Three or four loads of the order are accumulated on the storage conveyor. The corrugator trolley car operator pushes these loads onto the car for moving to the cooling storage section. This one trolley operator moves all the production from two double-cut-off corrugators.

The car is fully loaded. There are four lines of conveyors on the car, as many as eight 72-in. sheet length loads can be carried at one time. The operator rides facing forward when loaded, for safety reasons, and to determine what storage lines have been emptied. The operator has a factory order check, identifying the order.

When the operator has found a storage line with sufficient capacity to hold either the entire order or a good portion of it, the loads are pushed onto this conveyor. The factory check will be noted with conveyor number. When the order has been completely stored the factory check will be given to the printing foreman. Special lines have been set aside for work that goes directly to the die cutters or for slitting. Two slitter scorers are located within this line of conveyors, their finished work will flow out in the same direction.

As I previously mentioned, these aluminum plates are necessary, when the rollers are more than 4 in. apart. In one plant, I visited, when they run short of plates for riders during the day's activities, use heavy weight scrap, folded over, bottom piece corrugation against the roller direction. Most of their track sections are 4-in. centered rollers. When the rollers are this close, the bottom sheets or riders do not "belly" between the rollers and the loads can be pushed along fairly easily.

Some plants are using two strips of aluminum about 4 in. wide and 24 in. to as long as necessary under the load. Solid plates will usually last longer than these strips, give a better ride, and not allow jams as the greatest portion of the bottom sheets of the pile are resting on solid plate.

To keep the aluminum expense to a minimum, odd and

end lots and sometimes rejected pieces can be purchased from metal dealers. 24 or 17 ST, hard, aluminum lasts longer than the softer grades. Thickness should be between 0.008 and 0.010 in.

Masonite, plywood, and other materials have been tried by many plants. These wood products splinter and chip easily, weigh more, are bulkier to handle, besides resulting in numerous first aid visits to remove splinters from hands.

Advantages of the System to This Point

1. All loads have been moved with a minimum of physical effort.
2. No specialized or skilled help are required to move the loads. The initial movement from corrugator to storage lines was made by the sheet catchers as part of their routine. The one car operator who moves the sheets into cooling storage is general floor help.
3. The work is organized for future operations, falls into straight lines, moved easily and quickly located and controlled.
4. Loads are steady, and the paper is not jam-packed together, trapping the heat. Even and rapid cooling on all sides is obtained.
5. The load heights and quantities of sheets per load are fairly even and meet the unloading standards for the next operation.
6. Loads are not "buried or lost" as their storage location is on record.
7. The floor space required for the transfer car and temporary storage conveyors at the cut-off end is no greater than would be required for other methods.

An electric storage battery operated trolley transfer car is used to move the loads across the aisles. An inexpensive motor directly driving the axel through sprecket and chain provides the motive power. The operator has a simple forward and reverse button that controls movement. The car cannot move without the operator controlling it. Speed geared down, is directly proportional to motor speed. Braking is done by reversing the motor. The car travels on track imbedded in the floor, as the vanishing trolley car did, hence the name "trolley."

Originally these cars were standard Logan design manual operated. Power conversion was made by the plant maintenance crew from an idea of the plant superintendent.

This particular car and its operator supply the board from cooling storage to 12 printers and rotary slotters up to 160 in. in size. The car operator is informed by the printing foreman of the next job on a press. As the location of the loads is already known, marked on the check by the previous car operator, he quickly locates them and feeds them to the press. This car is also used to bring "fall offs" around.

The trolley operator pushes a load onto the feeder transfer car of a printer slotter. Beyond the car is sufficient track to store additional loads for constant press feeding. The trolley operator places these into position immediately after the last load of the preceding job has been run off.

The press feed transfer car moves in and out, depending on the width of the sheet being fed. The carry distance from conveyor to press is always at a minimum with sufficient room behind the press for the feeder to operate the press at its maximum efficiency.

The printer operator and his helper pile blanks onto the transfer car. This car also moves in and out, depending on the blank width. When the necessary load height is reached (height of finishing equipment governs load height), the car is pushed back to the stationary take-out track and the load is pushed onto it.

The trolley operator moves a load from the press take-out track onto the car. He will then move this load, as well as others, to the finishing marshalling area. He will note on the factory order check the track numbers and give the check to the finishing foreman.

The presses located on the feed aisles have short feed conveyor sections and long take-out sections. The presses on the take-out side have short take-out and long feed. The press area was so designed to accommodate a maximum number of machines within as small an area as possible.

Both the feed and take-out printing area car operators are only 75% productive. It is impossible to utilize this free time in the area, as the men are on a minute's call to feed the presses when they fall out of work. Originally, when the cars were manually operated, the feeding and removing operations accounted for a full days work with more concentration required to the short tracked presses.

Every system has its good and poor points. The cost evaluation of the conveyor system versus other one-level systems for this over-all operation, showed that conveyors would pay for themselves within a short time even with the following disadvantages.

Disadvantages of the System to This Point

1. Every roller conveyor section is a safety hazard the moment it is placed on the floor. The personnel have been warned many times not to walk on the frames or rollers to cross the tracks. Wood and metal walkways have been provided between the end two rollers of each section, car, and trolley. Even with these walkways, at least once during the year, a lost time "falling on conveyor" accident occurs.
2. The material flow is constricted to the line up of the conveyors. There is no deviation from conveyor to conveyor, unless other means of movement are used.
3. The storage areas available are limited to the numbers of conveyors placed within a given floor area. Approximately one-and-a-half times as much floor space is required to store an equivalent footage on conveyors as is on other one level systems. Aisles between conveyor sections and building posts account for the increase. All the storage facilities are "live" and immediately accessible, however.
4. It is impossible to completely utilize a given set of conveyor tracks as the various loads cannot be jockied about that easily to take advantage of every foot of conveyor space. Nor can double tiering of loads be made to use air space.
5. The width of the trolleys and therefore the width of the aisles must be wide enough to carry the longest sheet produced. These aisles are at least one-and-a-half times as wide as is necessary for other systems.
6. Preplanning the layout of equipment and flow of work requires a precise engineering analysis.
7. Sometimes it is difficult and involved to make relayouts for new or additional equipment, due to the fixed arrangement of the production flow. A lower operating cost possible by such addition has to be forsaken.

The semiautomatic taper machines were built to take full advantage of the stability of 6 ft. of paper riding on the conveyors and not having to be rehandled between the printers and tapers. Approximately 400 to 500 sheets per load of boxes, 5 to 30 sq. ft. can be so moved.

At the bundling stations of three semiautomatic tapers, the counter stacker ejects the counted bundles to the curved skate wheel conveyors. Only through the use of these curved skate wheel conveyors is it possible to bring the output of the three machines together for two bundlers. These two bundlers tie, single or cross, pile the bundles on transfer cars on either plates, pallets or skids, and push their completed loads out onto take-out sections. These two men will handle mixed box footages ranging from 5 to 60 ft. without any other help.

The feed and take-out elevator conveyor was designed and built in the plant to eliminate the rehandling of the sheets usually necessary at a die press location. Full loads, 5 ft. in height on conveyor, are fed, without rehandling directly from either the corrugator, slitters, or printers, by transfer trolleys, to the feed conveyor on the right. When the feeder has completed his previous load, he drops the right or feed side of the elevator level with the floor conveyor and moves the new load into position. When the feed end is down, the top sheet of the load is at the correct height for the feeder to pick-off easily. The take-out elevator is also at the correct height. As the feeder progresses through the load, he constantly levels off both sides, with a foot actuating switch, providing a level working height on both sides at all times.

The feed floor section can hold from two to four loads, depending on the sheet size, providing the feeder with a continuous back log of work. The take-out floor section holds the equivalent amount, enabling the die press supervisor to move the strippers from press to press without having to wait for feeder production. Management is in the process of developing a pool stripping crew either traveling from press to press or centrally located in a section of conveyors.

A double ended trolley car, two-man operated, is used to move the finished work to the shipping department. Three different types of loads can be handled on the car: a pallet, a bale, and a bundled load. Aluminum plates are used under all three for easier riding.

The shipping area has three banks of conveyor tracks, one for immediate shipment, one for next day shipment, and a set in the back of the area for hold or assembly of parts orders.

The shipping trolley men are briefed by the shipping supervisor on the orders coming from finishing. Thus, they know what order to place on what track for what truck. Those orders for next day or for hold, the track numbers are marked on the check. When shipment time comes, the order can be located and moved quickly to the track leading directly to the assigned truck.

The finished goods are moved directly from the immediate shipment bank to the inside of the trucks by means of the transfer car and portable sections located in the truck. The truck loaders do not have to carry the bundles at all.

A special feed conveyor line in the finishing area is used to marshall car load orders. Lift trucks pick off the pallet or bale load from the end of the conveyor and carry them to the freight car.

My son, who is a railroad enthuiast, asked me when I was writing this, "Why not call the talk, 'Corrugated Rides the Rails.'" Aptly it could be called just that.

SUMMATION OF ADVANTAGES

What are the sum total of the advantages of this system over others.

A. Labor Saving

1. All loads are movable with a minimum of physical effort.
2. Specialized or skilled help is not required for movement.
3. Work can be organized so that it falls into straight lines, is easily located, moved easily, and controlled.
4. Provides a controlled storage bank at all times. Periodic inventories can be easily obtained without using a large working force to move loads, or having to climb up, down, and around to identify the job and gather the data. The entire storage bank is "live" and easily accessible.
5. Difficult moves, such as long hauls or going up and down floor grades can be self powered to eliminate all physical handling.

B. Movement and Storage

1. Scheduling of prime moving equipment is not necessary.
2. Rehandling of the product between operations, such as onto the semiautomatic finishing lifting conveyor or boosting to a die press feeding conveyor is eliminated.
3. Maximum use of certain labor saving auxiliary equipment is possible. Such as: (a) counter stackers at the delivery end of finishing equipment, (b) counter stackers at cylinder die press, and (c) automatic banding equipment for making bulk shipping loads depend on conveyors for feeding, removing, and turning the loads for two-way strapping.
4. Loads are not "buried or lost" for any period of time.

C. Eliminates Delay Times

1. There are no delays waiting for specific prime moving equipment to remove loads from an operation.
2. There is no handling of empty carting equipment, wheel trucks, dead skids by either a prime mover, or physical effort from shipping to the various operations.
3. Empty conveyor sections are ready to receive their loads instantaneously. Trucks, skids, etc., have to be prepositioned before use at the various work stations.

D. Physical

1. Conveyors have a very low obsolescence factor. Replacement is nil.
2. Maintenance and repair is at a minimum. This company spends no more than 100 hr. a year on conveyor maintenance. Inventory of spare parts is very small.
3. Minimum floor wear and tear. Practically no floor maintenance required. In one plant, $15,000 was spent to recondition floors damaged by a wheeled operation. A few years later the plant was conveyorized. Initially that $15,000 could have purchased a major portion of the conveyor needs, and the floor could have been left as is.

COST COMPARISON OF VARIOUS SYSTEMS

Briefly let us compare some rough cost comparisons on this plant operation.

The internal handling of this plant producing 8 to 10 million ft. per week, one shift, is being performed by just eight general helpers; two have not been accounted for in the tour, they are in the specialties department.

A wheeled operation to achieve the same mobility and the same degree of labor efficiency would require an estimated 30 general floor men plus a very heavy investment in wheeled trucks. One maintenance man full time would be required to keep these trucks operational.

Using mechanical methods to perform the work load at the same efficiency level would require at least 12 skilled or specialized prime mover operators with at least 14 pieces of equipment (two spares); plus one skilled truck mechanic with a large inventory of truck spare parts; a heavy investment in a large number of wheel trucks or an equal number of skids; at least one maintenance mechanic to keep these in necessary repair. This type of equipment also carries at least a 10 to 15% obsolescents or replacement factor.

If a balance sheet were to be made of the three systems, capital investments would be approximately the same. The maintenance and replacement costs of the other two systems would balance out in the course of the year the additional rental cost for the greater floor area required for a conveyor system.

The savings then would be in the direct and indirect labor necessary to operate and maintain the system.

This plant moving 8 million ft. on conveyors requires eight nonskilled men or 1 man per million feet.

This plant operating as a wheeled operation, estimated, 30 nonskilled, 1 skilled: 31 total or $2^1/_2$ men per million feet.

Operating as a mechanical operation, estimated, 12 skilled movers plus 2 skilled maintenance: 14 total or $1^3/_4$ men per million feet. We would also have to account for the differential in wage scale.

The conveyor system is the nearest approach to automation in a job converting shop. If you are interested in changing to conveyors, I have one word of caution. Allow a qualified industrial engineer to work with you before you build, buy, or modify your building. As in all precise concepts, preplanning can save you future extra costs and grief.

Presented at the Eighth Corrugated Containers Conference of the Technical Association of the Pulp and Paper Industry, Cincinnati, Ohio, Nov. 4–6, 1958.

Ninth
Corrugated Containers Conference
Jung Hotel, New Orleans, La., Sept. 15–17, 1959

Presseal the Self-Sealing Container

E. G. SWANSON AND R. L. REID

The method of closing a container by the application of a pressure-sensitive adhesive applied by the manufacturer is not a new development. For many years it has been offered by the envelope, mattress bag, and shirt band manufacturers. In fact, there are many corrugated and fiber box manufacturers who have had the idea for many years. All of these people are aware of its advantages. The reason for the Presseal method of closure being unique is due to a number of reasons. In the past, when a pressure-sensitive material has been used, the carton design has always been modified to permit the use of the adhesive. In other words, a special carton design was necessary in order to make this type of closure. Presseal allows us to apply a pressure-sensitive adhesive in such a manner as to make a carton collapsible and stackable after the adhesive has been applied. This is accomplished by the use of varied pattern types. Realizing that no matter how good a coating machine was manufactured the program would only be as good as the adhesive itself, the first phase of the program was devoted almost entirely to the development of a proper adhesive. After a proper adhesive had been found, work was started on the development of the proper type of applicating equipment. The first type being by spray gun, then a unique type of roll coater was discovered. From this has evolved the type of equipment that is being used in Salinas, Calif., and Jacksonville, Fla. Market acceptance of Presseal was slow at the beginning, due to economics, however, as better equipment was produced and the cost of Presseal was lowered, the demand grew until it was impossible to keep up with it. Continued development work is being done in order to lower the price and to have a wider acceptance of Presseal.

THE method of closing a container by the application of a pressure-sensitive adhesive, applied by the carton manufacturer, is not a new idea. Patents go back as far as the 1800's and it has been previously offered by the envelope, mattress bag, shirt, and folding box industries. In fact, there are many corrugated and fiber box manufacturers who have worked on this idea.

Some of the features that make such an article in the container field attractive are:

1. Less floor space is required in a packing operation. No stitching machines are required. Floor space for assembled cartons is diminished. Floor space for sealing machines is eliminated.

2. Down time and setup time is cut to a minimum. These are two big factors when using stitching and case sealing machines.

3. Less assembly time. Persons packing can normally assemble the carton as well as pack it. Usually this accounts for a savings in labor which justifies the upcharge for the processed carton.

4. A neater package. This is an intangible, but nevertheless a quality package is important.

5. Cleanliness of operation. This is also an intangible. Neater operation means less cleanup time and a labor saving.

These advantages were the primary reasons for developing a way to make such a container available to the packaging industry.

The reason for the Presseal method of closure being unique is due to a number of reasons. The patent search made prior to the filing of the Presseal patent showed that in most instances the carton was designed around the position of the pressure-sensitive adhesive application. In other words, a special carton design was necessary in order to use this type of closure.

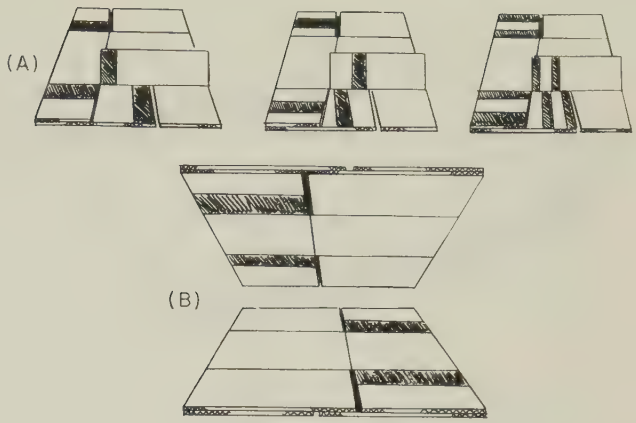

Fig. 1. Pressealed containers

(A) Collapsible (B) stackable

By the use of various type patterns, the Presseal adhesive can by applied to most any RSC or HSC container. By the use of these patterns, a Pressealed container is both collapsible and stackable. This is the basic premise of the patent.

The Presseal application no. 606,097 has had five claims allowed covering these basic patterns. A patent has been filed with the U. S. Patent Office based on the claims that have been allowed and will be issued within 60 days.

Illustrations of the basic pattern designs are shown in Fig. 1 through 7.

ADHESIVE

One of the reasons the development of the self-sealing type of carton has been slow in developing is due to the fact that a special type of pressure-sensitive adhesive is necessary. The Presseal adhesive is quite different from that used in similar methods of closing. It has been compounded to withstand as much as possible, the effects of dust, air, and sunlight. Over 300 pressure-sensitive adhesives have been tested since the beginning of the program. To date only one formulation has been found acceptable, but a continuous program of adhesive evaluation is being carried on.

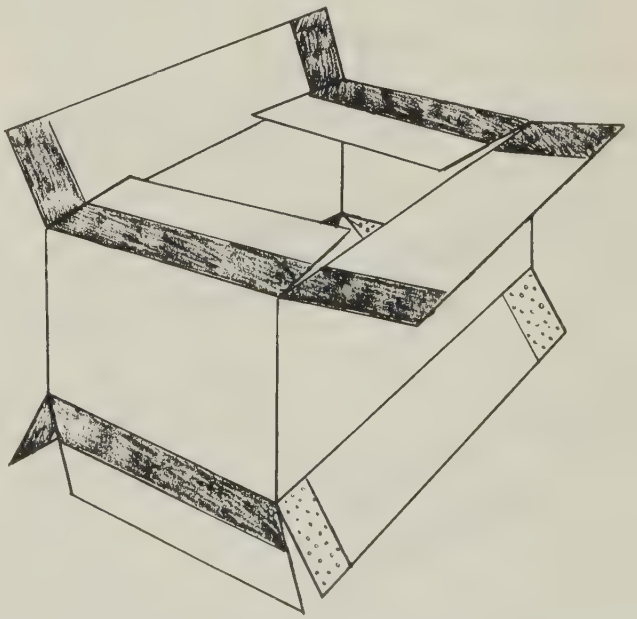

Fig. 2. RSC container; regular pattern—top and bottom

E. G. SWANSON, Manager, Product Development Dept., Growers Container Corp., Salinas, Calif., and R. L. REID, Manager, Fullerton Div., Growers Container Corp., Fullerton, Calif.

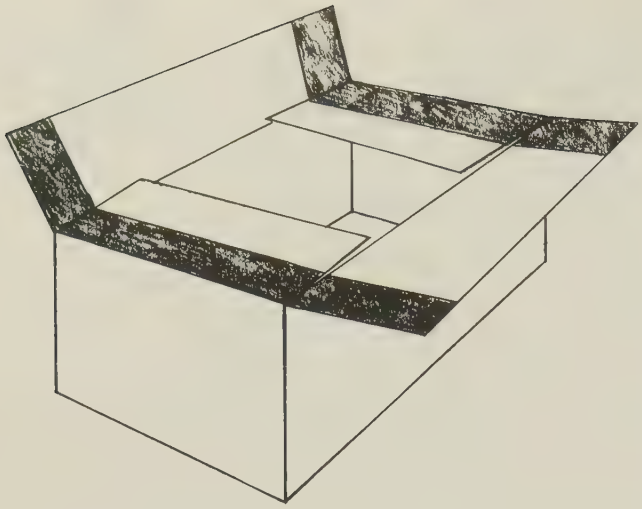

Fig. 3. Half-slotted container—regular pattern

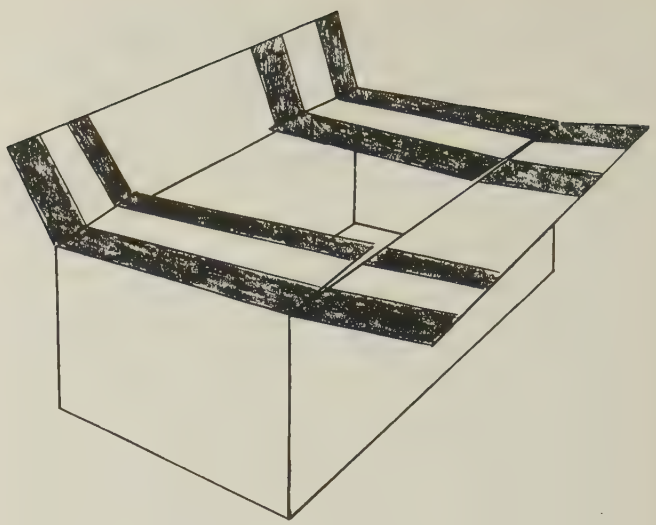

Fig. 5. Half-slotted container; split pattern

It has been found that regardless of the means of application, the basic characteristics of the adhesive must remain the same. As a result of this, the specifications for the acceptance of an adhesive in the Presseal is as follows:

Adhesive Specifications

1. Machining Characteristics. The adhesive must be compounded so that foaming does not occur during high speed operation. The amount of defoamer cannot be of such high concentration as to allow crawling or fisheyes to appear either on the transfer rolls, dies or adhesive pattern. The adhesive must have the proper machining characteristics so no throwing or stringing occurs.

2. Blocking. The adhesive after being applied by the Presseal machine to a carton blank and allowed to dry in the drying section must not show signs of offset and/or blocking when subjected to 1.2 p.s.i. pressure for a period of not less than 7 days at 75 ±2°F. At the end of this period the tack and bonding characteristics must not be impaired.

3. Shelf Life. The shelf life of the liquid Presseal adhesive must not be less than 90 days.

The adhesive after it has been applied to the carton and the cartons bundled and properly stored should bond satisfactorily after 1 year storage.

4. Tack. The adhesive must have sufficient pressure sensitive qualities so that when the affected areas are in intimate contact and under pressure an adequate bond is formed, yet not possess tack in the amount that blocking occurs.

5. Oxidation Resistance. The liquid adhesive must be so formulated that it will withstand the effects of small amounts of copper, manganese, and other materials deleterious to the stability of the liquid adhesive.

The affected areas after being properly applied and dried must possess sufficient resistance to ozone and ultraviolet light so as to withstand a minimum of 2 hours' exposure to atmospheric conditions such as found in the Salinas Valley area, and still form a satisfactory bond.

In the very beginning of the program, it became evident that it was necessary to determine the amount of contact flap area to be covered by adhesive in order to obtain a firm bond. A minimum amount of application was required in order to make this type of closure competitive. These tests were not only conducted in our laboratory, but also by an independent laboratory. The first tests were run under Tariff 1-E, Fresh Fruits and Produce, and here it was found that 40% flap contact area was sufficient to obtain an adequate seal. Previously the tariff required that 100% of the flap contact area be covered with adhesive. Actual shipping tests proved 40% coverage of the flap contact area sufficient to do the job.

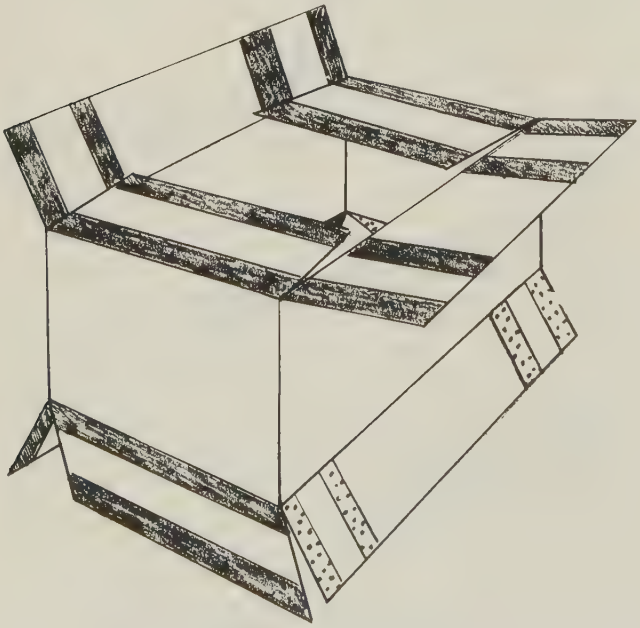

Fig. 4. RSC container; split pattern—top and bottom

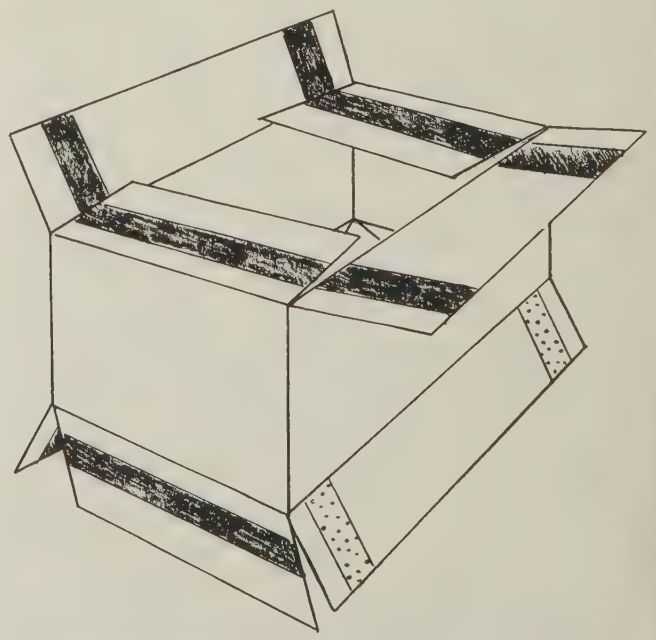

Fig. 6. RSC container; offset pattern—top and bottom

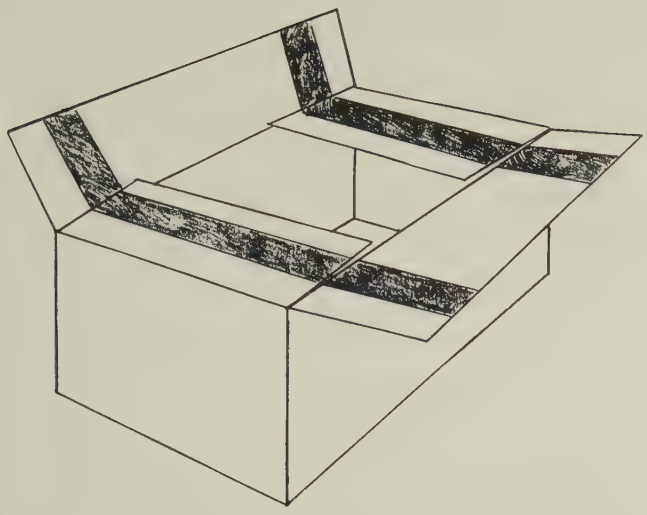

Fig. 7. Half-slotted container; offset pattern

Pressealed containers are now accepted under Tariff 1-E and 823-C.

Since that time, the performance of Pressealed containers under Rule 41 has been gathered. Its use under various types of shipments has been closely watched. Additional tests have been run to determine its position under Rule 41. The results of the laboratory tests and the actual performance under shipping conditions will be brought before the Uniform Freight Classification Committee at their next meeting for reviewal.

In the course of testing, there are some features in the bond strength of Presseal that have been brought out. Regular adhesives and tape bonds are about equal in a shear strength and in tensile strength. This is due mainly to the fact that they are not highly plasticized and thus they show good fiber failure when the container is opened.

Pressealed containers have moderate tensile strength, but high shear strength. Thus, the bond acquired on sealing does not tear as many fibers when parted. We are of the belief that under normal shipping conditions that the glue bond undergoes more shear stress than tensile stress and this is the reason less pressure-sensitive adhesive is required than with normal adhesives.

The adhesive application has been tested in its unsealed and sealed conditions. Under normal storage conditions, it will retain its optimum characteristics for six months. Test cartons properly stored have been sealable after 2 years of storage. Temperatures up to 120°F. induce no blocking as long as the maximum pressure of 1.2 p.s.i. is not exceeded. Storage at −40°F. does not impair the sealing characteristics as long as the film is allowed to return to room temperature before sealing is attempted. The final bond will pass all the tests of a waterproof adhesive as required by the specifications set up in MILA 101. Humidity does not seem to impair the self-sealing qualities of the Presseal application.

METHODS OF APPLICATION

There are two basic methods of application, spraying, and roll coating. Each method has its advantages.

On the spray type machine the adhesive is applied to the end and side flaps of the container after the manufacturer's joint has been formed. The end flaps are depressed inward and the side flaps outward and the erected box is then conveyed through the machine. The feeding is done either manually or automatically. After the adhesive is applied, it passes under a section of radiant heaters for drying. The containers are then collapsed, stacked, and bundled for shipment.

The setup time on machines of this type is low, speeds moderate, and production is limited to RSC and HSC. Uneven caliper in board is not a problem and there is less chance of scuffing the film due to repeated handling when passing through other equipment in the plant.

The second type applicator can be best described as a modified roll coater. In this machine the adhesive is applied by rubber pads traveling with a speed differential in relationship to the board.

The blanks after going through the printer-slotter are run through the Presseal equipment. After the adhesive has been applied, it passes through a radiant drying section and from that into an air drier from which they emerge dry and cool. The next step is to fabricate the manufacturer's joint.

Machines of this type are not limited to a particular carton design and have a higher production capacity. The initial cost is higher and space requirements are greater. Care must be taken when fabricating the manufacturer's joint on the container, as scuffing can occur impairing the self-sealing properties of the adhesive.

PRESSEAL IN INDUSTRY

Over 35,000,000 containers have been Pressealed and used in industry in the past 6 years. In the beginning the majority of the containers were used in the produce industry. However, in the past 2 years the trend has been reversed and now the biggest use is in industrial packaging.

Some of the commodities now being packed are paper products, meat, prepared food, paints, roofing material, nuts and bolts, milk, frozen foods, seeds, etc. In using Presseal containers they have effected savings in their operation which justifies the upcharge.

A good example of this is a cost study made by a frozen food concern. A breakdown of their comparative closing costs was as follows:

Comparative Costs of Closure Methods Based on Cost of Closing 1000 Boxes

1.	Presseal Top and Bottom			
	Presseal cost	$13.50		
	Labor cost	4.00		
		$17.50		
	Less labor sav. (by eliminating one man)	8.50		
	Actual Presseal cost			$ 9.00
2.	Glued Top with Glued Bottom			
	Labor	$ 8.50		
	Material	2.25		
	Total cost, top and bottom			$10.75
3.	Glued Top with Stitched Bottom			
	Glued top:			
	Labor	$ 4.00		
	Material	1.13		
			$5.13	
	Stitched bottom:			
	Labor	$ 6.67		
	Material	2.25		
			$8.92	
	Total cost, top and bottom			$14.05
4.	Taped Top with Taped Bottoms			
	Taped top:			
	Labor	$ 4.00		
	Material	2.35		
			$6.35	
	Taped bottom			
	Labor	$ 6.67		
	Material	2.35		
			$9.02	
	Total cost, top and bottom			$15.37
5.	Taped Top with Stitched Bottom			
	Taped top:			
	Labor	$ 4.00		
	Material	2.35		
			$6.35	
	Stitched bottom:			
	Labor	$ 6.67		
	Material	2.25		
			$8.92	
	Total cost, top and bottom			$15.27

Labor and Material Cost Breakdown

Presseal: Upcharge for frozen food case in carload quantities equals $13.50 per thousand.
Labor Cost. We can close 500 Pressealed cases an hour. Labor rate of $2.00 an hr. equals $4.00 for 1000 cases. We can eliminate the man who sets up the box and glues at a rate of 240 an hr. or $8.50 per 1000 cases.

Therefore: Presseal cost	$13.50
Labor cost	4.00
	$17.50
Labor savings (By eliminating one man)	8.50
Actual Presseal cost	$ 9.00

Glue: 0.083 per lb.: 9 lb. equals 1 gal. on $0.75 a gal. Takes 3 gal. to close 1000 boxes, top and bottom or $0.75 × 3 equals $2.25.
Labor Cost. Average speed is four a minute or 240 an hour for top and bottom.
Labor rate of $2.00 an hr. equals $8.50 for 1000 boxes.
Labor and material cost for 1000 boxes equals $10.75

Wire: Acme steel—$0.28 a pound: 1 lb. yields 1500 stitches. Average 10 stitches to a box bottom equals 10,000 stitches for 1000 boxes. 10,000 stitches equals $6^2/_3$ lb. $6^2/_3$ lb. at $0.28 a lb. equals $1.87 for 1000 boxes.
Labor Cost. Average speed is five per minute or 300 an hour. Labor rate of $2.00 an hr. equals $6.67 for 1000 Stitched Bottoms.
Labor and material cost for 1000 stitched bottoms $ 8.54

Tape: 250 roll price equals $0.805 a roll or 600 ft. 1000 ft. equals $1.34 based on a box size 15 in. long and 6 in. deep equals 21 in. of tape per box or 21,000 in. per 1000 boxes or 1750 ft. 1750 ft. equals $2.35 for bottom or top only. Top and bottom equal $4.70.

Bottoms—*Labor Cost.* Average speed—5 per minute for bottoms only for 300 an hr. Labor rate of $2.00 an hr. equals $6.67 for 1000 bottoms.

Tops—*Labor Cost.* Average speed—nine per minute or 500 an hour. Labor rate of $2.00 an hr. equals $4.00 per 1000 tops.

SUMMARY

The need for a self-sealing container has been met with Presseal. Its wide acceptance in industry evidenced by the use of over 35,000,000 containers show them to be practical whenever the containers are being hand-sealed.

Presented at the Eighth Corrugated Containers Conference of the Technical Association of the Pulp and Paper Industry, Cincinnati, Ohio, Nov. 4–6, 1958.

Prediction of Short-Time Static Compressive Strength of Corrugated Containers

B. S. ANGELL AND P. R. PASLAY

The results of analytical and experimental studies to determine the short-time, top-to-bottom compressive load carrying capacity of commercial corrugated fiberboard containers are presented here. Where containers are designed such that the contents carry no top-to-bottom load (as is the case for the containers investigated here) prediction of the failure load is essential for warehouse stacking considerations. An analytical procedure to predict failure loads and evaluate design changes for containers of large panel dimensions is developed for use by packaging engineers. Corrugated containers for three different home electric range packs were tested in short-time, top-to-bottom compression and the results compared with predicted failure loads. The comparison clearly indicates that once the governing physical properties of the combined board are known, corrugated containers can be designed, analyzed, and tested in a manner similar to other structures in engineering. Details of obtaining the necessary physical properties of combined board are included as well as the application of SR-4 strain gages to combined board. A simple illustrative example is given applying the recommended procedure to a particular carton. This work helps to explain the mechanism of container failures due to warehouse stacking which have been observed many times in the field; it will also help the packaging engineer to evaluate design changes of a container by a more rational procedure than the "test and see" philosophy.

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Widespread use of corrugated fiberboard containers during the past decade has focused attention on the lack of technical knowledge in this field. For example, warehousing of large cartons as investigated in this paper demands that they withstand sizable compression loads, yet the fundamental physical properties of the material have not been available so as to adequately design such a container for the imposed loads. Developing these cartons by trial and error methods without a rational basis for the application of the material is an expensive process. The high dollar cost of our ignorance is emphasized by the fact that packaging may represent 5 to 10% of the total material cost of the product. It was to gain more knowledge as to the behavior of corrugated containers subjected to top-to-bottom loading that the project reported here was initiated.

The following will serve as a brief history of the problem. In the latter part of 1954, the Range Department of the General Electric Co. at Louisville, Ky., introduced an all-corrugated pack for their home ranges to replace the wire-bound containers previously used. The packs were of the flanged-tube and cap construction with saddles and a wooden skid base and were stacked five high in the warehouse. In

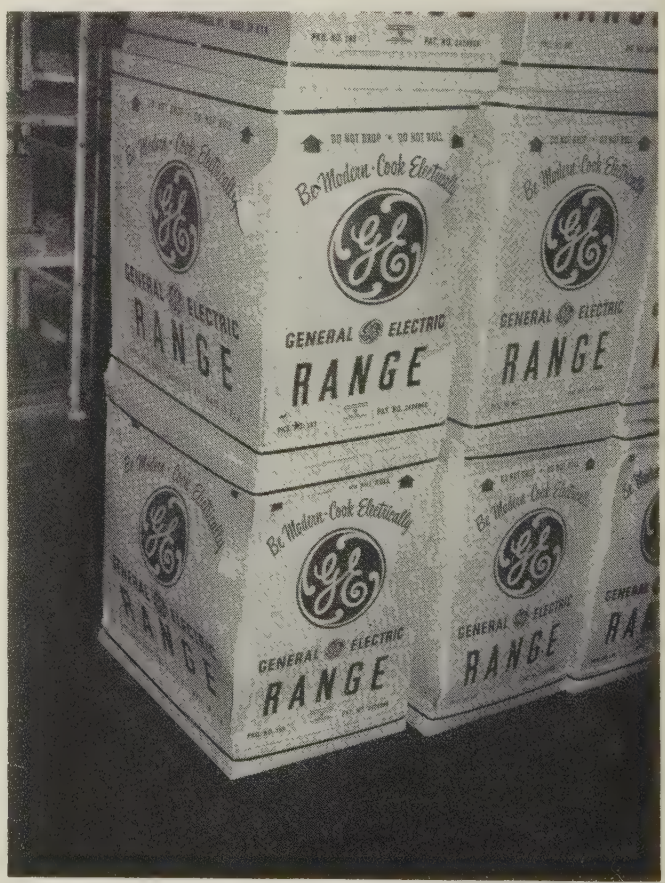

Fig. 1. Typical container failure in warehouse

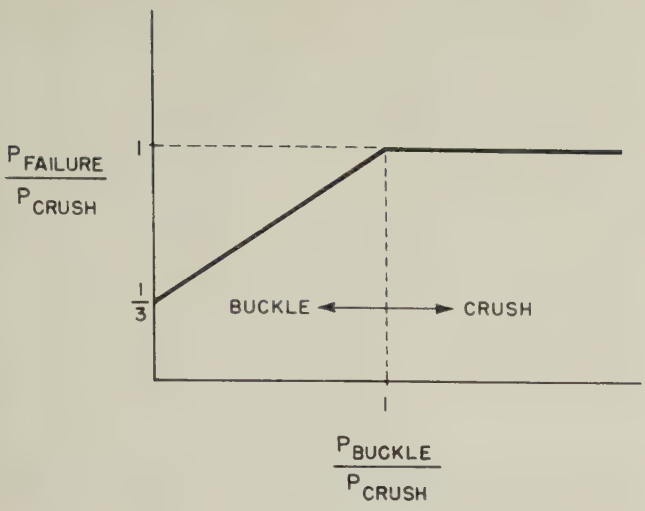

Fig. 2. Panel failure load versus initial buckling load

the spring of 1955 there was evidence of compression failures after storage in the warehouse for as little as 24 hr. in a high temperature and relative humidity environment. All failures were similar, being of a buckling nature. It should be borne in mind that the contents of these packs carry no top-to-bottom load, it being taken entirely by the corrugated container. Figure 1 is a photograph of a typical warehouse failure.

The authors were approached by C. L. Fay (then of the Range Department) to determine whether it was possible to predict in advance the structural integrity of the range packs, subjected to certain loading and environmental conditions. Numerous investigators have studied the effect of time and environmental conditions on the physical properties of corrugated fiberboard (*1*, *2*); a task group of the ASTM D-10 Committee is also studying the effect of containers subjected to dead weight loading for periods of 6 months or longer.

In view of the above, the authors decided to conduct a fundamental study of the mechanics of short-time compressive strength of corrugated containers, in particular those of large panel dimensions. This study includes the prediction of failure load due to a combined buckling and crushing action of the tube. Numerous studies have been made of this problem, the most comprehensive of which are probably the work of Kellicutt and Landt (*2*) and Maltaenfort (*3*). Due to the empirical nature of their approaches, it was decided that a more fundamental analytical study should be made and the results compared with data already available as well as with experimental tests on the range packs referred to above. A brief discussion of the analytical study, experimental verification of predicted failure loads, comparison with other available data, and a sample design calculation are found below. For a more thorough treatment of the study, the reader is referred to other publications by the authors (*4*,*5*).

RESULTS

Analytical

The study considers that failure of a container may occur due to a crushing action or a combined crushing and buckling action occurring simultaneously. The analysis shows that for an assumed load distribution across the panel width, the theoretical failure load of a tube panel P_{failure}, is a function of the initial buckling load, P_{buckle}. This is shown in Fig. 2 in simplified form. Appendix A gives the derivation of the formula and the assumptions made. When the ratio of the initial buckling load to crush load, $P_{\text{buckle}}/P_{\text{crush}}$, is known, then the failure load of a tube panel, P_{failure}, can be found from this graph. In order to calculate $P_{\text{buckle}}/P_{\text{crush}}$, (refer to eqs. A-1 and A-2, Appendix A), one must know certain physical properties on the combined board as well as the dimensions of the panel under consideration. The required physical properties are the-bending stiffnesses of the board in its two principal directions, D_1 and D_2, the torsional rigidity of the board, 2 $(GI)_{xy}$ and the crushing strength of the board in the load-carrying direction, $N_{y\ \text{crush}}$. These properties of the board used in the containers tested by the authors were obtained experimentally at standard conditions; a complete description of these tests may be found in references (*4*) and (*5*). It should be emphasized at this point that all physical property measurements were made on samples of the *combined board* used in the containers tested; it was deemed more significant and certainly no more difficult to obtain the crushing strength by testing the combined board itself instead of summing the crushing strengths of the board components.

The average unit panel failure load for a particular board can be plotted versus panel width for various width to height ratios once the physical properties of that board are known. Figure 3 shows a plot for 275-lb. test A-flute kraft board at standard conditions. Similar plots could be made for all commercially available boards once their physical properties have been determined. Figure 3 will be used later in the paper to determine the theoretical failure load of a tube used in one of the range packs which were tested.

Top-to-Bottom Container Tests

Three different sizes of containers (24 in., 30 in., and 40 in. range packs) were considered in the experimental phase of this study. Table I gives the pertinent information for each container together with typical physical properties of the tube materials. It should be noted at this point that all range packs contained a folded corner post in each corner of the pack which actually accounts for about half of the total failure load. However, this paper contains the results of only the tube failure loads.

Top-to-bottom compression tests were performed on a National Forge direct-drive testing machine in the Packaging Laboratory of the General Electric Co. in Schenectady. The top platen of the machine is of swivel construction and power driven to apply a compressive load at the rate of $^1/_2$ in. per min.

All containers tested were conditioned for 48 hr. prior to testing at standard conditions in order to reach equilibrium conditions. Several tests were run for each size pack using virgin material throughout. Additional tests were run where the maximum loads at failure were widely separated until a systematic pattern developed. All tests were taken to failure where a sudden drop-off in load indicated complete failure of the tube. Table II shows the results of the tests, compared with predicted values of failure load by the authors'

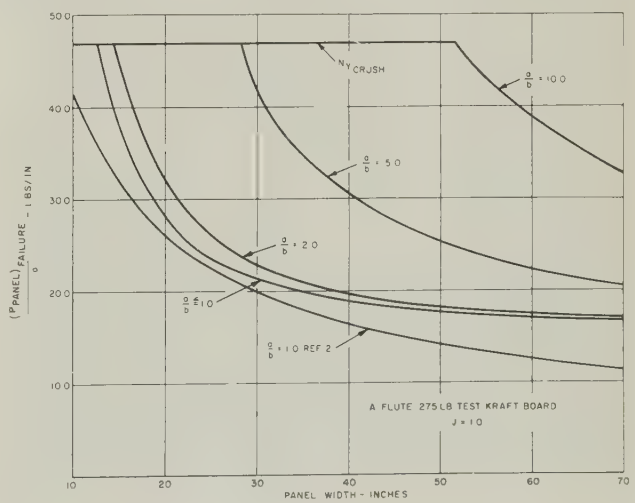

Fig. 3. Theoretical unit failure load of tube panel versus panel width

Table I. Description of Range Containers Tested

	Range size, in. 24	30	40
Manufacturer	General Box Co., Louisville, Ky.	Inland Container Corp., Middletown, Ohio	Inland Container Corp., Indianapolis, Ind.
Tube dimensions, in.	$29^3/_4 \times 26^1/_4 \times 47^1/_2$	$31^1/_2 \times 29^1/_2 \times 47$	$43 \times 29^3/_8 \times 47^1/_2$
Tube material[a]			
Flute	A	C	C
Mullen test	275 lb.	275 lb.	275 lb.
Typical material properties			
Ny crush	46.8 lb./in.	52.0 lb./in.	49.0 lb./in.
D_1 = EI per inch	218 in.-lb.	120 in.-lb.	
D_2 = EI per inch	127 in.-lb.	83 in.-lb.	
$D_3 = {}^1/_2(\mu_x D_2 + \mu_y D_1) + 2(GI)_{xy}$	217 in.-lb.	115 in.-lb.	
Ultimate strength compression across M.D.	60 lb./in.	45 lb./in.	
Modulus of elasticity with M.D.	595,000 lb./sq. in. (22,600 lb./in.)	555,000 lb./sq. in. (20,000 lb./in.)	
Across M.D.	358,000 lb./sq. in. (13,600 lb./in.)	447,000 lb./sq. in. (16,100 lb./in.)	

Note: All containers are of the flanged tube and cap construction top and bottom. Vertical corner post in each corner of pack. Manufacturers joint-stitched One-half inch flat metal strap used for banding top and bottom caps. Contents fastened to wooden skid base.
[a] Fourdrinier kraft 69-lb. liners; semichemical 26-lb. corrugating medium; balanced construction.

formula, and those due to Kellicutt and Landt (*2*) and Maltenfort (*3*). The results have also been plotted in Fig. 5 for the six different panel sizes tested; this plot is similar to Fig. 2 but on an expanded scale. The best straight line through the experimental points shows that the theoretical failure load for a perfect tube, i.e., squared edges with no folds, should be multiplied by a factor of 0.7 to obtain the failure load for the flanged construction used in the range packs. This "flap coefficient" or "box factor," $J = 0.7$, is the same value that was found from tests on regular slotted containers (*2*).

Sample Failure Load Calculation

As stated previously, once the required physical properties of a particular board are known, plots similar to Fig. 3 can be made by use of the theory developed in the Appendix and reference (*4*). The factor J must be determined for every top-to-side type of panel construction or for particular pack designs which include corner posts such as the range packs studied by the authors. With the above information known, a sample calculation to determine the short-time failure load of a 24-in. range container tube follows:

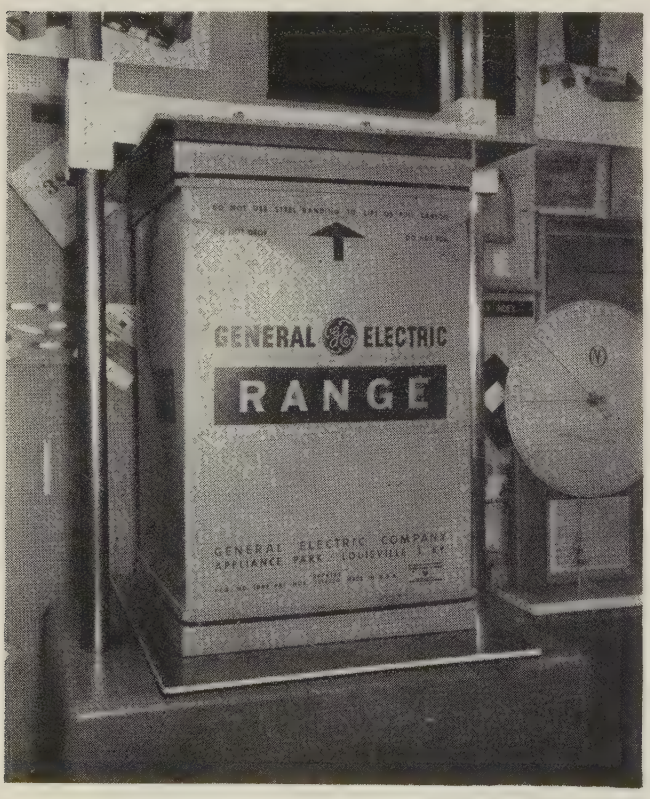

Fig. 4. Thirty-inch range container in testing machine at failure

24-Inch Range Container Tube

Panel widths	Panel height
$a_1 = 29^3/_4$ in.	$b = 47^1/_2$ in.
$a_2 = 26^1/_4$ in.	

From Fig. 3, curve $a/b \leq 1.0$

$$\frac{P_{\text{panel 1}_{\text{failure}}}}{a_1} = 21.3 \text{ lb./in.}$$

$$\frac{P_{\text{panel 2}_{\text{failure}}}}{a_2} = 23.0 \text{ lb./in.}$$

$$P_{\text{tube})_{\text{failure}}} = 2(21.3 \times a_1 + 23.0 \times a_2)$$
$$= 1268 + 1208$$
$$= 2476 \text{ lb. (compared to 2468 lb. calculated directly from formula)}$$

Assuming a flap coefficient, $J = 0.7$

$$P_{\text{container})_{\text{failure}}} = J \times P_{\text{tube})_{\text{failure}}}$$
$$= 0.7 \times 2476$$
$$= 1743 \text{ lb. (compared with experimental value of 1780 lb.)}$$

As a matter of interest, the factor J obtained for the range pack tubes with corner posts installed but not taking any top-to-bottom load was 0.85; their effect in this case is one of preventing excessive bowing of the panels and, therefore, increasing the initial buckling load.

Use of SR-4 Strain Gages

As mentioned above and in the Appendix (eq. A-4), a load distribution at failure across the panel width was assumed in the analysis from practical considerations. For small values of $P_{\text{buckle}}/P_{\text{crush}}$ the accuracy of the predicted failure load depends to a large degree upon how well this assumed load distribution agrees with the actual distribution

Table II. Comparison of Experimental and Predicted Failure Loads

	Range size, in. 24	30	40
1. Container failure load—experimental, lb.	1780	1720	1660
2. Tube failure load predicted by authors' formula, lb.	2468 (0.72)	2492 (0.69)	2662 (0.62)
3. Tube failure load predicted by reference (*2*), lb.	2340 (0.76)	2180 (0.79)	2180 (0.76)
4. Container failure load predicted by reference (*3*), lb.	1420 (1.27)	1438 (1.20)	1502 (1.10)

Note: Figures in parentheses give ratio of experimental failure load to predicted failure load. For lines 2 and 3, this is equivalent to a "flap coefficient," J.

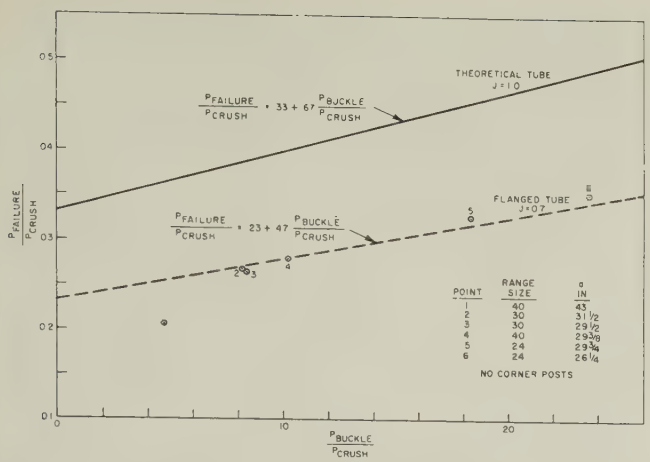

Fig. 5. Experimental failure load of flanged tube panels versus initial buckling load

of a container panel at failure. In order to check this assumption a 30-in. range container was instrumented with SR-4 wire resistance strain gages and subjected to top-to-bottom compression loading. More technical detail concerning the strain gages themselves can be found in Appendix B as well as references (*4*) and (*5*).

Axial and transverse strain readings were taken at various stations along the mid-height section and near the top cap section of the $31\frac{1}{2}$ in. wide panel for various container loads. From these data and prior calibration of gages applied to sample combined board which gave the reinforcement factor and modulus of elasticity, the load distribution shown in Fig. 6 was obtained for the midheight section. As can be seen, the load distribution tends to shift with applied load in a manner predicted by the theory.

DISCUSSION OF RESULTS

As mentioned previously, once the fundamental physical properties for a given board are known, plots similar to Fig. 3 can be made by use of the authors' suggested formula (eqs. A-8 and A-9). The packaging engineer can then use such graphs to evaluate the effects of dimensions and/or material changes on the load carrying capacity of a container. Figure 3 shows that the authors' work is in close agreement with the empirical formula of ref. (*2*) for an a/b ratio equal to 1.0. The theory and its results were also checked by making a plot similar to Fig. 2 of the data for cubical tube tests (*2*). The data fall very close to the $J = 1.0$ line for values of $P_{buckle}/P_{crush} \leq 1.0$ (Fig. 24, (*4*)).

Comparing the values of the factor D_2 in Table I shows the advantage of using A-flute board for containers of large panel dimensions. D_2 being over 50% higher for A-flute board compared with C flute means a higher initial buckling load for A-flute board. This will result in a greater failure load as shown by Fig. 2. The orthotropic nature of fourdinier kraft board is shown by comparing the bending stiffnesses of the board in its two principal directions, D_1 and D_2, which are in about the same ratio as the moduli of elasticity. The change in modulus, machine direction versus across machine direction certainly overshadows any effect of geometry changes. Much more can be said regarding the physical properties of combined board and their determination, but they are of interest in this paper only insofar as they effect the load carrying capacity of a container.

Figure 5 shows that for the construction of the containers tested, a box factor of 0.7 applies, similar to RSC containers (*2*). It should be noted that the 43-in. panels of the 40-in. range packs tested experienced a no-load bow inwards of about $1\frac{1}{4}$ in. due to initial strap tightening. It is well known that any initial eccentricity reduces the buckling load greatly; this undoubtedly is the reason this panel falls below the predicted value for failure load.

CONCLUSIONS AND RECOMMENDATIONS

In view of the above, in the authors' opinion this work establishes that corrugated fiber boardcontainers can be designed and analyzed in a manner similar to other engineering structures. This study, besides explaining the mechanics of field failures observed many times should make possible a more rational design method for predicting stacking strength as well as evaluating design changes.

The reader should keep in mind that the theory developed in this paper has been verified by a limited number of tests for containers of comparatively large panel dimensions. It is highly recommended that interested packaging engineers plot the results of their container compression tests on a graph similar to Figs. 2 or 5 to see over what range the existing formula is adequate. For low values of P_{buckle}/P_{crush} the failure load of a panel is determined principally by the assumed load distribution and does not include the effect of initial eccentricity. At values of $P_{buckle}/P_{crush} \approx 1.0$, the existing theory does not include the effect of using the instantaneous stiffness of the board at higher strain levels instead of the slope of the stiffness curve at the origin. Notwithstanding, the results of containers exhibiting low initial buckling loads (see Fig. 5) are encouraging.

It is recommended, then, that further compression testing of corrugated containers be performed to verify the findings presented here. In order for the results to be meaningful, the required physical properties for the containers tested must be obtained under controlled conditions. It would be extremely helpful to the consumer if the vendor could furnish this information for crushing strength and bending stiffnesses of the combined board obtained from sample periodic tests. The consumer should also check these values for the material used in the containers to be stored in the warehouse using the same standardized test procedures for compression resistance and flexural rigidities. The latter are essential since the initial panel buckling load, P_{buckle}, is dependent upon the flexural rigidities of the board and not its strength properties (see eq. A-2).

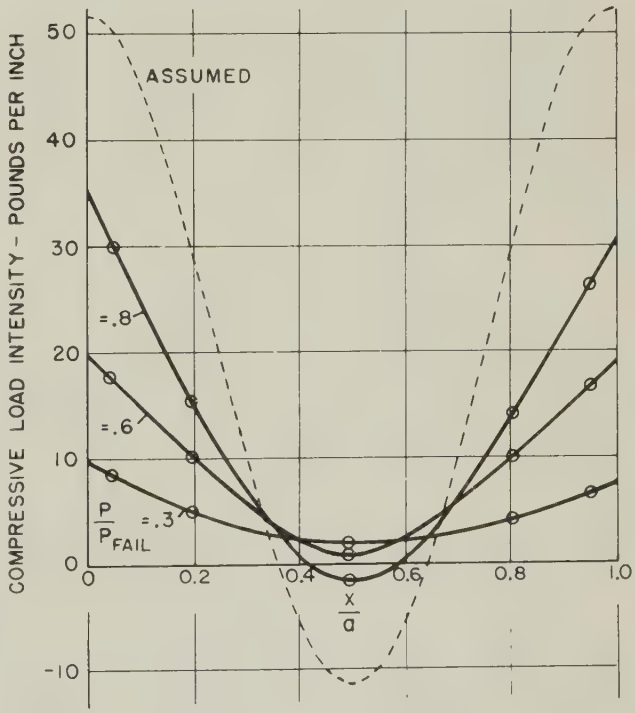

Fig. 6. Container panel load distribution versus panel width at mid-height section

Solid lines—measured load distribution at various stages of loading. Dashed line—assumed load distribution at failure.

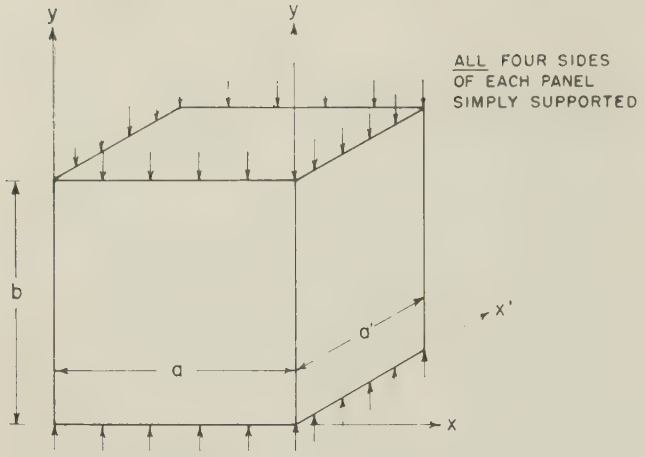

Fig. 7. Schematic diagram of container

From a long range point of view, this work indicates that treatment of corrugated fiberboard as an orthotropic elastic sandwich plate is a sound approach. Additional work in this area will further test this assumption and, as more experimental and analytical work is performed, the mechanics of corrugated board technology should become better understood.

Finally, the authors' believe the application of SR-4 strain gages directly to fiberboard for quantitative measurements is a significant feature of this paper. The gages are inexpensive, simple to apply, and require very little recording equipment. This technique should find widespread use in the fiberboard packaging industry.

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APPENDIX A—OUTLINE OF DERIVATION OF COMPRESSIVE FAILURE LOAD

If a panel simply supported on its four edges is subjected to a uniform edge load (see Fig. 7) whose intensity increases with time, it will eventually fail in one of two possible modes. These two modes are crushing and buckling. For crushing the load on the panel, P_{crush} is (2)

$$P_{\text{crush}} = N_{\text{crush}} \cdot a \qquad \text{(A-1)}$$

while for buckling the load, according to the usual linear theory for orthotropic plates, is (6)

$$P_{\text{buckle}} = \frac{n^2\pi^2 D_2 a}{b^2}\left(1 + \frac{D_1}{D_2}\frac{b^4}{a^4}\frac{1}{n^4} + 2\frac{D_3}{D_2}\frac{b^2}{a^2}\frac{1}{n^2}\right) \qquad \text{(A-2)}$$

where $N_{y_{\text{crush}}}$ is the unit compressive strength, D_1 and D_2 are the bending stiffnesses in the xx' and yx' planes, respectively, for the front panel of tube in Fig. 7, D_3 is given by formula in Table I, and n is a positive integer which leads to the lowest value for P_{buckle}. n is the number of half waves of the buckled configuration in the load direction.

In the case of a panel of a container stacked in a warehouse the top and bottom edges are required, from geometrical considerations, to remain straight. This means that the load distribution across the top and bottom edges is not necessarily uniform. Further, it is evident that the four edges of each panel are simply supported.

For crushing failure of the container panel equation (A-1) gives the correct load but for buckling the load given by equation (A-2) is not the load that causes failure. The buckling load given by equation (A-2) provided it is higher than the crushing failure load, is the point at which the load distribution ceases to be uniform. In order to find the total load on the container after buckling, it is necessary to determine the new load distribution. It is then assumed that the failure load, P_{failure}, is reached when the maximum point of this distribution first becomes equal to $N_{y_{\text{crush}}}$.

In this analysis an energy method is used to find the approximate shape of the post-buckled local distribution. The interested reader is referred to a detailed derivation previously given by the authors (*5*). This Appendix is intended to outline the principal parts of the derivation.

Essentially what is done is that the displacement normal to the plate, w, is assumed to be expressible as:

$$w = A \sin\frac{n\pi y}{b}\sin\frac{\pi x}{a} \qquad \text{(A-3)}$$

and the load distribution, $f(x)$, is assumed to be,*

* The form of (A-4) is motivated by the straight top and bottom boundary condition.

$$f(x) = N_{y_{\text{crush}}}\left(1 - C\sin^2\frac{\pi x}{a}\right) \qquad \text{(A-4)}$$

Now the change of potential energy and work done by the load distribution are calculated for a virtual displacement and are equated to give:

$$C = \frac{4}{3}\left[1 - \frac{\pi^2 n^2 D_2 a^2}{b^2 N_{y_{\text{crush}}} a}\left(1 + \frac{D_1}{D_2}\frac{b^4}{a^4} + 2\frac{D_3}{D_2}\frac{b^2}{a^2}\frac{1}{n^2}\right)\right] \qquad \text{(A-5)}$$

For the failure load, P_{failure}

$$P_{\text{failure}} = \int_0^a f(x)dx = N_{y_{\text{crush}}} \cdot a\left(1 - \frac{C}{2}\right) = P_{\text{crush}}\left(1 - \frac{C}{2}\right) \text{ if } \frac{P_{\text{buckle}}}{P_{\text{crush}}} < 1 \qquad \text{(A-6)}$$

or

$$P_{\text{failure}} = P_{\text{crush}} \text{ if } \frac{P_{\text{buckle}}}{P_{\text{crush}}} > 1 \qquad \text{(A-7)}$$

Substituting for C from equation (A-5) into (A-6) gives

$$\frac{P_{\text{failure}}}{P_{\text{crush}}} = \left[\frac{1}{3} + \frac{2}{3}\frac{\pi^2 n^2 D_2 a^2}{b^2 (N_{y_{\text{crush}}})a}\left(1 + \frac{D_1}{D_2}\frac{b^4}{a^4}\frac{1}{n^4} + 2\frac{D_3}{D_2}\frac{b^2}{a^2}\frac{1}{n^2}\right)\right] \text{ if } \frac{P_{\text{buckle}}}{P_{\text{crush}}} < 1 \qquad \text{(A-8)}$$

$$\frac{P_{\text{failure}}}{P_{\text{crush}}} = 1 \text{ is } \frac{P_{\text{buckle}}}{P_{\text{crush}}} > 1 \qquad \text{(A-9)}$$

or using equation (A-2)

$$\frac{P_{\text{failure}}}{P_{\text{crush}}} = \frac{1}{3} + \frac{2}{3}\frac{P_{\text{buckle}}}{P_{\text{crush}}} \quad \frac{P_{\text{buckle}}}{P_{\text{crush}}} < 1 \qquad \text{(A-10)}$$

$$\frac{P_{\text{failure}}}{P_{\text{crush}}} = 1 \qquad \frac{P_{\text{buckle}}}{P_{\text{crush}}} > 1 \qquad \text{(A-11)}$$

These results are shown graphically in Fig. 2.

Due to the approximate nature of the solution its predictions could only be expected to be accurate when the buckling load is only slightly smaller than the crushing load. The range of $P_{\text{buckle}}/P_{\text{crush}}$ over which the equations are sufficiently accurate depends on the validity of the assumed displacements and loading and must be determined by experiment. The assumed load distribution at failure, equation (A-4), was checked experimentally for a 30-in. range container

panel and found to be a very good approximation as shown in Fig. 6.

APPENDIX B—WIRE RESISTANCE STRAIN GAGES APPLIED TO COMBINED CORRUGATED FIBERBOARD

In order to determine the unit compressive membrane loading across the width of a loaded container panel, it was decided to use SR-4 wire resistance strain gages bonded to the outside surface of each liner. The reader is referred to other papers of the authors (*4,5*) for a more thorough treatment of this technique.

A fundamental study was initiated to determine the local effect of the gages applied to corrugated board. Type A-1 gages, $^{13}/_{16}$ in. gage length, were applied to test samples of combined board in each of its two principal directions and loaded both in tension and compression. Since the strain gage locally reinforces the combined board, by proper calibration using a mechanical extensometer, the value of this reinforcement factor was determined. The value of this factor, true strain/strain gage indication, varied between 1.05 and 1.20 for the boards investigated depending upon the orientation of the gages and strain level. During this calibration process, the unit load-strain curves as well as board modulus was obtained for various conditions of loading.

Knowing this relation, the true membrane strains, ϵ_x and ϵ_y were determined at several stations across the panel width of a loaded container panel. Using basic strength of materials relationships (*4*) p. 38) the unit panel loading was determined for each of the two principal directions. The unit loading of the panel in the y direction is plotted in Fig. 6 versus panel width for various panel loads.

SR-4 gages have the advantage of being readily available, easy to apply anywhere on the surface of the fiberboard, do not necessitate visual reading of the gage at the point of application, permit quick readings at a particular load condition, and require inexpensive indicating equipment.

Evaluation of the Water Resistance of Corrugator Adhesive Bonds

D. E. KANE

The increasing use of water resistant corrugating pastes, brought about by packaging such commodities as fresh fruits and vegetables in corrugated, has created a problem in evaluation of the water resistance of such pastes. A method of measurement could be of value in determining the effects of changes in paste formulations as well as in quality control. Conventional testing is usually subjective and frequently must be on a "satisfactory" or "not satisfactory" basis. A test, which consists of measuring the force required to break the wetted bond when the forces are applied to, and in the planes of, the liners, has been found to overcome some of the difficulties encountered with a subjective test. The test is described and factors affecting the results are discussed. Minimum bond strengths are usually reached within a 30 min. soaking time, and reliable results are frequently possible with as little as ten minutes soaking. Comparison of test results with subjective evaluation indicate that, while for one operator subjective results may be satisfactorily reproducible, variations between operators can be very large.

COMMODITIES such as lettuce and citrus fruits, as well as other fresh foodstuffs, are shipped to a large extent in corrugated boxes. Because of the low temperature and high humidity storage requirements of these commodities, the containers used must have some degree of resistance to strength loss when exposed to wet conditions. This demand for water resistance is usually met by the use of hard sized components combined with water resistant paste. We were concerned several years ago with this demand for water resistance in the paste, and desired to know whether or not it was necessary and, if so, what degree of water resistance was required.

The first part of this question was answered when we were experimenting with container stacking tests in which the loaded containers were subjected to condensation of varying intensities. One of the containers with which we were concerned was combined with a domestic paste. This container performed very well at low levels of condensation; however, at slightly higher levels it failed completely. Other containers, of generally lower stacking strength at the low levels of condensation, were affected only slightly by this higher condensation level. Examination of the collapsed containers revealed that some adhesive failure was involved. This demonstrated that at least under severe conditions, container failure could involve adhesive failure which might be avoided by the use of water resistant paste.

At the time of these tests, our only method of testing for the water resistance of corrugator pastes required soaking the board for 24 hours and examining it at the end of this time for voluntary separation. To overcome the possibility that the surface tension of the water might hide small areas of voluntary separation, a light thumb pressure was applied to the liners and any resulting separation was called "voluntary." We believed that this test method could be reliable only in separating board with very good water resistant paste from board with practically no water resistance. This was generally borne out in the frequent, complete disagreement between test results from different laboratories on presumably identical samples.

As a result of this lack of reliability in the subjective test, we were asked to develop a more satisfactory test for the measurement of the water resistance of corrugator paste bonds.

DESCRIPTION OF TEST

A consideration of the purpose of the adhesive suggested that the most desirable method of testing the adhesion would be with a shearing force, rather than a normal tensile or peeling action. The testing technique which evolved is shown schematically in Fig. 1. The sample is cut 1 in. wide in the cross machine direction, with the length just sufficient to include 12

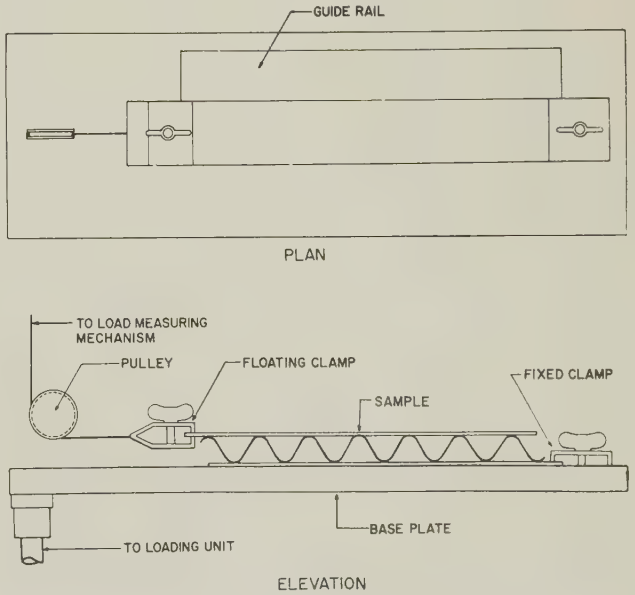

Fig. 1. Schematic of wet adhesive bond tester

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glue lines on each liner. The wetted sample is held in position by clamping one end of the bottom liner to the base plate. A second, floating clamp, is attached to the opposite end of the top liner. This clamp is attached by a cable to the weighing mechanism, with the angle of pull controlled by a pulley around which the cable passes. The load is applied by moving the base plate. The testing unit may be attached directly to a conventional tensile tester, using its loading and weighing system. However, our plants have self contained units with the loading accomplished by hand wheels and spring scale weighing units.

The angle of pull, controlled by the height of the pulley above the base plate, has not been found to be critical over a range of about ±2° from the horizontal. Therefore the height of the pulley has been adjusted to give a horizontal pull with C-flute board. The distance from the sample to the pulley is then made great enough so that the pulling angle falls within these limits for other flutes. This point has not been investigated over a wider range of angles to determine how the measured strength varies with the greater deviations from a horizontal pull.

The force is applied in the machine direction of the board as a matter of convenience. Liners are easily clamped when the sample is cut in this manner; and, more important, the wet tensile strength of some light liners is too low in the cross machine direction. Failures consequently take place in the liner rather than the adhesive bonds. Liner failure in the machine direction is not uncommon; however, the wet strength of the liner in this direction is usually greater than the wet adhesive bond strength necessary for satisfactory board. In those instances when this is not true, the number of glue lines tested may be decreased. This point has been checked, varying both sample width and sample length; and, within the precision of the test, the wet bond strength has been found to vary directly with the length of adhesive bond tested, from 6 to 24 in.

TESTING VARIABLES

The soaking time required for the bonds to reach minimum strength varies with the type of paste used. However, with the conventional pastes used in corrugated board, the minimum strength level is usually reached within thirty minutes. Frequently, satisfactory results may be obtained with as little as ten minutes soaking time. When this minimum strength level is reached, further soaking, even for 48 hr. has little effect on wet bond strength.

Practically all of our work has been carried out in an air

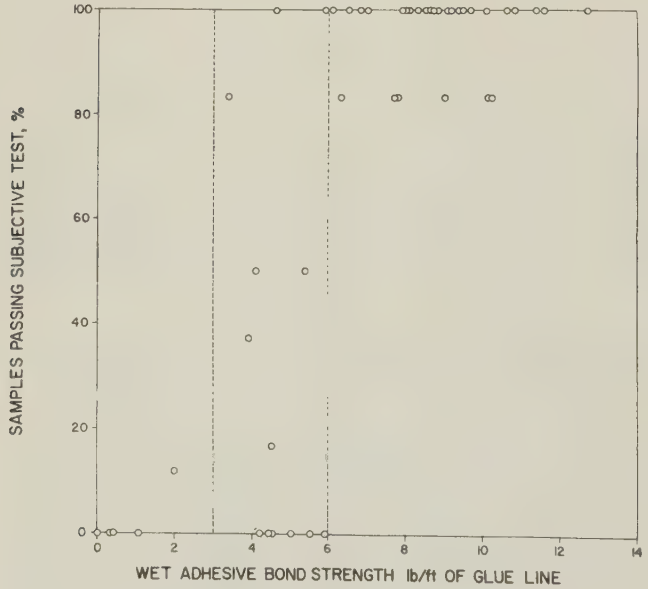

Fig. 2. Relationship between wet adhesive bond strength and subjective wet adhesion test results

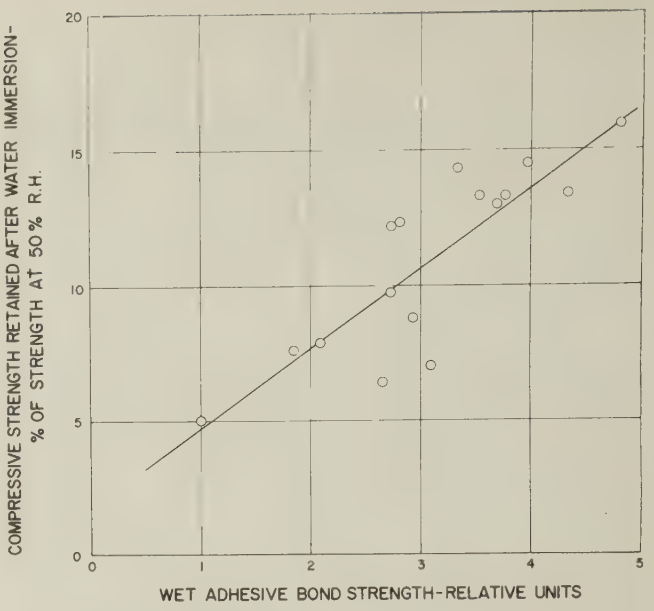

Fig. 3. Relationship between wet adhesive bond strength and top-to-bottom compressive strength of wetted containers

conditioned laboratory with the temperature controlled around 73°F. While a study of the effect of water temperature has been carried out, it was not comprehensive. Indications were, however, that temperature control to approximately ±3°F. was desirable to obtain reproducible results.

Prior to the use of the wet bond tester, impurities in the water had been suspected of causing variations in the evaluation of the water resistance of pastes. Since the concentration and number of possible impurities, and combinations of impurities, in water from various sources makes any complete investigation out of the question, we used deionized water for our most critical studies. We have, however, investigated the effects of a number of calcium and sodium salts commonly found in ground water, and found that the effects of these materials on wet bond strength was negligible. Even the addition of a surface active agent to the soaking water has caused no significant change in the measured strength of the bonds.

As in most strength tests on paperboard, the measured wet bond strength is dependent upon the rate of application of the load. This is most apparent in static loading. With a pendulum weighing device, we use a loading rate which applies 10 lb. in about 20 sec. However, rates of one half to one and one half times this have produced only slight variations in the test results.

The effect of flute on the test results is still questionable. Generally speaking, A-flute gives lower wet bond strengths than B-flute. This may be due to an inherent weakness in the test method, but the comparison has never been made under closely controlled conditions where the only major variable involved was flute size. Regardless of the cause of the difference, the effect of flute on test results make it imperative that the same flute size be used when making a comparison between different adhesives. In such a comparison, it is, of course, desirable to make other board characteristics as nearly identical as possible so that the variation in results can be properly attributed to differences in adhesive properties.

One factor which has interfered with our study of this test is the effect of age of the board upon the wet bond strength. This aging has not been studied extensively, but apparently depends upon the degree of cure obtained on the corrugator as well as upon the type of paste used. Increases of 100% in wet bond strength are not uncommon in the first few months of board storage.

RELATIONSHIP TO OTHER TESTS

An extensive comparison of the wet adhesive bond test results with the subjective "thumb" test has been carried out by another laboratory. The results of part of this comparison are shown in Fig. 2, where the fraction of samples failing the subjective test is plotted against the wet bond strength. Six samples were used initially in the subjective tests, and, if more than one of these samples showed separation, an additional 24 samples were tested. The wet adhesive bond test results are averages of five tests for each sample. All of the results shown here were from tests on A-flute, 200-test board. Similar tests on B-flute board did not give clear cut results, since few of the samples failed in the subjective test. Figure 2 indicates that boards having a wet bond strength of less than 3 lb. per ft. usually failed the subjective test. In the range of 3 to 6 lb., wide variations in results, from passing to complete failure, were possible. Above 6 lb. no differentiation in bond strength was possible. In our laboratory, a similar, less extensive, study of this relationship indicated that boards in the 2 to 4-lb. range would usually be passed in the subjective test.

Attempts have been made, since the development of the wet adhesive bond test, to determine the strength level necessary for satisfactory performance of water resistant paste. No answer to this question has been found, since the strength required in the paste appears to depend upon type of board used in the container. The only general statement which we can make is that, ideally, the adhesive should possess sufficient strength so that the board, when exposed to the most severe field conditions expected, should suffer no loss in stiffness due to adhesive failure. The higher the wet stiffness of the board components, the greater the need for strength in the adhesive bond to obtain the ultimate wet stiffness of the board.

Figure 3 illustrates the relationship between wet bond strength and wet compressive strength for one class of water resistant containers. The board in these containers is all made to the same specifications insofar as flute, board test, and degree of sizing is concerned. The containers used in this particular study have been further selected on the basis of uniformity of board caliper. On the basis of their uniformity of construction and end use, we might expect that they would retain approximately equal proportions of their dry compressive strength after they had been immersed in water for 30 min. This particular method of evaluation was used because we have had some success with it in predicting field performance of these containers. It is apparent, however, from Fig. 3 that the strength retained varies with the wet bond strength, which is shown here in relative units. The data are, unfortunately, inadequate to show whether or not the retained strength reaches a constant level at high wet bond strengths, as might be expected. Examination of the containers after testing did reveal, however, that separation of the liners from the medium took place up to a relative wet bond strength of three to four. The leveling out of the curve would not be expected until the wet bond strength was great enough to prevent any such separation or slippage. Bond strengths above this level would appear to be unnecessary. When properties other than board stiffness are of primary importance, however, an entirely different level of bond strengths might be desirable. These data are presented here only to indicate that this method of testing the wet bonds yields information on wet bond strength which is related to the ultimate performance of the container. The data are completely inadequate for any other application.

CONCLUSION

It is apparent that the test method described here lacks much of the understanding and study required of a precision test. Arbitrary control of the test conditions, within rather close limits, is called for since a variety of paste formulations are in use. A test variable known to be of little significance with one formulation could be of major importance with a different paste. The results obtained, however, do indicate that a useful measurement is being obtained. A practical means of comparing the water resistance of adhesives on a reasonable basis is therefore offered. Furthermore, the test offers a means to study the relationship between field performance and bond strength to a degree not previously available.

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Unitizing and Bale Packing of KD Corrugated Boxes

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A discussion of the unitizing, palletizing, and baling of KD corrugated boxes and the amazing growth of larger units that are replacing string tied bundles. How methods of doing this job have improved over the past five years and what is necessary to have a profitable operation. Some plants have been slow to change to efficient methods and are using too much manpower. Other plants have made changes to streamline their unitizing operation and are in position to go after this market vigorously. Different types of units now being specified by corrugated box accounts and what is necessary to arrive at the most economical unit. A brief description of strapping tools and strapping and compressing equipment available for unitizing and bale packing and a discussion of plant layouts that make this work economical is presented. Methods of transferring units from stacking line to main strapping line and also methods of turning units when cross-strapping is necessary are discussed.

In the last five years, we have all witnessed a tremendous growth in unitizing of KD corrugated containers in place of individual string tied bundles. Probably 50% of all boxes produced today are now unitized, palletized, or baled. The trend continues upward, sparked by the large number of high-speed gluers being installed. Because string tying is the bottle-neck in high-speed production, more and more boxes go into large steel strapped units. One man can stack into units from a high-speed gluer, but if string tied bundles are being run at least two men are required.

Three factors are largely responsible for the rapid growth of unitizing in the last five years: (1) modern power handling equipment, (2) high labor cost of loading and unloading individual bundles, and (3) high-speed box finishing equipment.

The unusual thing about the growth of unitizing is that the demand came from the box user. Most corrugated box plants did not promote the unitizing idea, at first, and some plants are still lukewarm to this method of handling boxes.

The change from string tying (a method in use since the industry was born) to unitizing, presented major problems for the corrugated box industry. But many box plants have solved the problem by installing proper tools and equipment, setting up a central compressing and strapping station and in some cases even moving finishing equipment. Portable compression stations have not been successful because no. 1 press is too heavy to move easily and no. 2, if two or more finishing units are turning out units, it is too much trouble to switch the press back and forth.

Customer's specifications as to type of unit has complicated the box maker's problem. While the majority of box users are satisfied with a corrugated sheet on the top and bottom,

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other accounts want separators and some accounts demand skids or pallets. The simple unit witn a corrugated or waster sheet top and bottom is winning in the popularity contest and will continue to grow as more box plants promote this idea. This unit is, of course, the least expensive and easiest to put up. And the unit may be placed on a pallet at the receiver's plant if pallets are an air in storing. The popularity of the unit with separators or voids will decline as more receivers become accustomed to picking up the unit with thin blade forks. The same can be said for skids and pallets although for one reason or another there will always be a few accounts that have special needs.

Some few box manufacturers have made a determined sales effort to push the simple unit with a corrugated sheet top and bottom strapped in one direction only and have simplified their unitizing work. Others through the cooperation of their own plant personnel and the receiving personnel of the customer have had specifications changed with profit to both. Your sales people are seldom inclined to question customer's specification on units, but in spite of this fact, progress is being made diplomatically toward one type unit.

Most of the container plants with a large volume of unitizing have gone through several phases before arriving at the modern, up-to-date, time-saving methods which are in use in some plants today. As a first step in unitizing they started out with two-piece hand strapping tools, strapping the unit at the finishing machine. Step 2 was usually a change of power tools to give predetermined tension. Step 3 in many cases was a home-made compression unit sometimes in conjunction with a simple conveyor setup. Step 4 is the F3B strapping machine and turntable in conjunction with a transfer track system or a conveyor system (sometimes powered) which connects all finishing machines.

Many plants in spite of increased unitizing are still struggling with an outmoded method requiring too much time and too much manpower. Some plants are stymied to a degree because of plant layout. But from all the evidence, unitizing is here to stay and anything done now to improve plant layout and cut unitizing costs will pay dividends for years to come.

We will discuss the equipment available today for unitizing and bale packing corrugated boxes plus layouts which effect economies. The big majority of plant managers believe compression is necessary, and it is a fact that when compression is used, straps need not be applied so tight that they damage the edges of the units. While compressing and strapping equipment is important, the task of conveying units from the finishing machine to the strapping station is equally important—and one cannot be considered without the other. You are all familiar with the many manual and power strapping tools available. For a small unitizing operation such tools are sufficient. For best results a power stretching tool that can be set for predetermined tension should be used so that straps are applied sufficiently tight but without damaging the edges of the unit.

In an effort to improve their unitizing operations many box plants have built homemade compression machines although there are as many different versions as there are plant superintendents. Beacon Machinery Co. builds a low cost hydraulic compression machine which may be secured in either a floor or overhead model. So for a cost of around $2000.00 you can build or buy a compression machine. With a two-man crew you can strap 10 to 15 units per hr. with a conveyor setup. Two men are necessary to arrive at any speed because most of the time is taken up with threading of the strap. One piece combination power tools can be used in conjunction with these presses.

For the corrugated box plant with a large volume of unitizing the fastest and most widely used compression and strapping machine available today is the F3B strapping machine. This machine furnishes 6200 lb. of compression and applies one, two, or three straps simultaneously in a cycle time of 30 sec. Permanent strap spacing at 15 or 30-in. intervals has worked amazingly well. The F3B machine must be set up as a central compression and strapping station and all units funneled to it. But this machine is still of little value to the corrugated box plant without a well thought out method of transporting stacked units of corrugated boxes from the finishing machines. With an efficient layout, one operator can strap up to 200 units in an 8-hr. day.

Because some cross strapping of units will always be necessary, some turning device is necessary next to the strapping station and here are three ideas now in use in the order of their popularity:

Pneumatic cylinder	$250.00
Ball transfer unit	$250.00 to $1000.00
Caster unit	$250.00
Two-way conveyor	$1000.00

And now we come to the "bale-pack" about which many of you are curious. The bale pack has been promoted on the West Coast for the past three or four years and is growing in favor in that region particularly Northern California. It is estimated that 10 to 15% of West Coast production is bale packed, while 60 to 70% is unitized. The big advantage of the bale is that it can be made to stack two across in truck or freight car and use all available space. The big disadvantage up to now is that the bale pack requires the use of wood pallets.

A simple horizontal unit for compressing the bale pack can be purchased for about $850.00. With this press an overhead hoist is necessary to remove and stack the bale.

A semiautomatic bale press, turner stacker and accumulator is available at a cost of $8750.00. One operator with this equipment can turn out around 12,000 boxes per hr. A number of West Coast corrugated box manufacturers are now equipped to produce both the bale pack and the unit pack and with competition being what it is, more corrugated box manufacturers will be so equipped in the future.

As of today unitizing is by far the most popular method of shipping KD corrugated boxes, and bale packing is but a ripple in the vast sea of corrugated box production. However, there are avid supporters of both methods and I guess only time will give us the answer.

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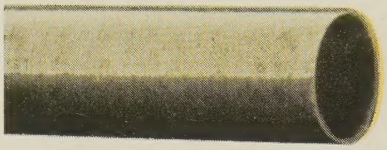

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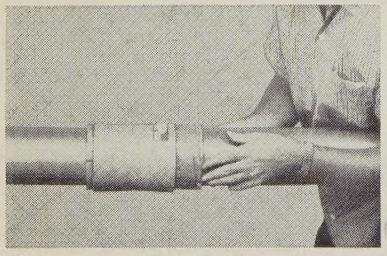

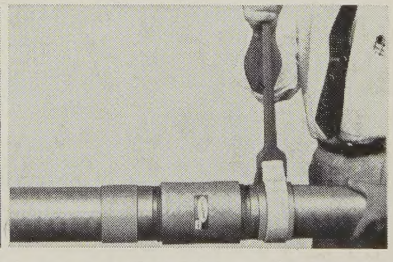

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